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800-531-9977 customerservice@mcelroytranslation.com

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(12) KOKAI TOKOUHYO PATENT GAZETTE (A)

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(71) Applicant: 000006013
Mitsubishi Electric Corporation
2-2-3 Marunouchi, Chiyoda-ku, Tokyo

(72) Inventors: Makoto Miyake
Mitsubishi Electric Corporation
2-2-3 Marunouchi, Chiyoda-ku, Tokyo

Kakutaro Koyama
Mitsubishi Electric Corporation
2-2-3 Marunouchi, Chiyoda-ku, Tokyo

(74) Agent: 100102439
Kaneo Miyata, patent attorney and 1 other

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(54) [Title] WIRELESS COMMUNICATION SYSTEM, COMMUNICATION CONTROL METHOD FOR WIRELESS COMMUNICATION SYSTEM, AND MANAGEMENT METHOD THEREOF

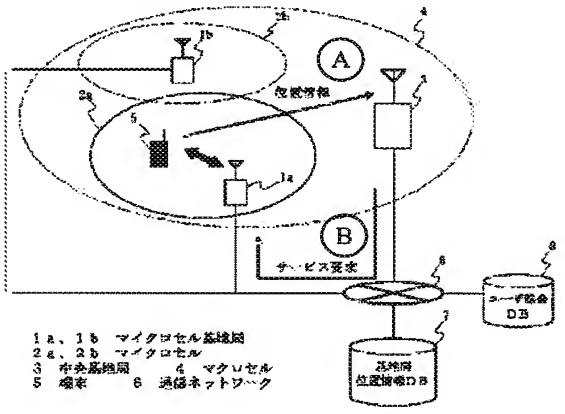
(57) Abstract

Problem to be solved

To provide high-speed data communication service to mobile terminals while suppressing an increase in the transmission power of the entire wireless communication system.

Solution

In an wireless communication system consisting of a central base station that uses macrocells covering a wide communication available area, microcell base stations that are capable of high-speed data communication, and terminals, the aforementioned terminals have a communication speed determination means that determines whether or not a communication speed higher than that between the aforementioned central base station and a terminal is required when a data communication request is received and a connection control means that transmits a control signal of high-speed data communication request when the aforementioned communication speed determination means determines that a higher communication speed is needed, and the aforementioned microcell base station uses a microcell



Legend:

1a, 1b	Microcell base station
2a, 2b	Microcell
3	Central base station
4	Macrocell
5	Terminal
6	Communication network

whose communication available area is smaller than that of the aforementioned macrocell when a control signal containing a high-speed communication request is transmitted from the aforementioned terminal and establishes a wireless connection to the aforementioned terminal to conduct data communication at a higher speed than that of the central base station.

Key: A Position information
B Service request
7 Base station position information DB
8 User charge DB

Claims

1. A wireless communication system consisting of a central base station that uses macrocells covering a wide communication available area,

microcell base stations provided within the aforementioned macrocell and capable of higher speed data communication than that of the aforementioned central base station,

and terminals that are wirelessly connected to the aforementioned central base station and conduct data communication at a low communication speed, characterized by the fact that

the aforementioned terminals have a communication speed determination means that determines whether or not a communication speed higher than that with the aforementioned central base station and a terminal is needed when a data communication request is received and a connection control means that transmits a control signal of high-speed data communication request when the aforementioned communication speed discriminating means determines that a higher communication speed is needed, and

the aforementioned microcell base station uses a microcell whose communication available area is smaller than that of the aforementioned macrocell when a control signal containing a high-speed communication request is transmitted from the aforementioned terminal and establishes a wireless connection to the aforementioned terminal to conduct data communication at a higher speed than that of the central base station.

2. The wireless communication system according to Claim 1, characterized by the fact that a plurality of microcell stations are provided in the macrocells and in addition a base station position information database is provided wherein the respective position information of the aforementioned plurality of microcell base stations are recorded in advance,

the terminals have a position information generation means that detects the position information of a terminal and the connection control means conducts transmission by including the aforementioned position information in the control signal of high-speed data communication request,

the aforementioned base station position information database specifies a microcell base station capable of wireless connection with the aforementioned terminal based on the respective position information of the aforementioned plurality of microcell base stations and the position information of the terminal included in the aforementioned control signal of the high-speed data

communication request, and said specified microcell base station establishes a wireless connection to the aforementioned terminal to conduct high-speed data communication.

3. The wireless communication system according to Claim 1, characterized by the fact that a plurality of microcell stations are provided in the macrocells and in addition a base station position information database is provided wherein the respective position information of the aforementioned plurality of microcell base stations have been recorded in advance,

the central base station has a direction detection means that estimates the incoming direction of the wireless signals transmitted from a terminal requesting high-speed data communication, a reception intensity measurement means that measures the reception intensity of the wireless signals transmitted from the aforementioned terminal, and a terminal position estimation means that estimates the position of the terminal based on the incoming direction and reception intensity of the aforementioned wireless signals,

the aforementioned base station position information database specifies a microcell base station capable of wireless connection with the aforementioned terminal based on the respective position information of the aforementioned plurality of microcell base stations and the position information of the terminal estimated by the aforementioned terminal position estimation means, and the concerned specified microcell base station establishes a wireless connection to the aforementioned terminal to conduct high-speed data communication.

4. The wireless communication system according to Claim 2 or 3, characterized by the fact that the base station position information database is constituted to calculate the communication speed of the data communication capable of being used by said terminal based on the position information of the terminal, and

the communication speed determination means is constituted to make an inquiry regarding the usable communication speed for data communication to the aforementioned base station position information database before starting the data communication and allows the user of the concerned terminal to select the data communication speed to be used in the data communication based on the information related to the usable communication speed for data communication that was notified from said base station position information database.

5. The wireless communication system according to one of Claims 1-4, characterized by the fact that the terminals are provided with a quality request determination means that determines whether or not high-speed data communication of favorable communication quality is needed when the communication speed determination means determines that high-speed data communication is needed, the connection control means transmits a control signal of a high-speed communication request including a high quality communication request when said quality request determination means determines that high-speed data communication of favorable communication quality is needed, and

the microcell base station specified by the base station position information database expands said microcell according to the aforementioned high quality communication request to conduct high-speed data communication with the aforementioned terminal.

6. The wireless communication system according to one of Claims 1-4, characterized by the fact the terminals are provided with a quality request determination means that determines whether or not high-speed data communication of favorable communication quality is needed when a determination is made that high-speed data communication is needed, the connection control means transmits a control signal of a high-speed communication request including a high quality communication request when said quality request determination means determines that high-speed data communication of favorable communication quality is needed,

the base station position information database specifies all microcell base stations in a predetermined area that includes the aforementioned terminal according to the aforementioned high quality communication request, and said specified microcell base stations transmit the respective data to the aforementioned terminal.

7. The wireless communication system according to Claim 5 or 6, characterized by the fact that the terminals have a moving speed detection means that detects the moving speed of said terminal and the quality request determination means can determine that high-speed data communication of favorable communication quality is needed when the aforementioned detected moving speed is greater than a predetermined threshold value.

8. The wireless communication system according to any of Claims 1-4 provided with a microcell base station control means that controls a plurality of microcell base stations characterized by the fact that

the communication speed determination means determines on whether or not a higher communication speed than that of the communication speed between the central base station and the microcell base stations is needed when a data communication request is received and when it is determined that high-speed communication is needed, the connection control means transmits a control signal of a high-speed, large-capacity data communication request to the aforementioned microcell base station control means, and the microcell base station control means that received said control signal transmits multiple transmissions by plural stations of the transmission data to the aforementioned terminal via the plurality of microcell base stations specified by the base station position information database.

9. The wireless communication system according to Claim 8, characterized by the fact that the connection control mean transmits a control signal of a high-speed large-capacity data communication request by including information related to the requested communication speed,

the microcell base station control means that received said control signal calculates the maximum communication speed capable of being provided according to multiple transmissions

by plural stations via a plurality of microcell base stations specified according to the base station position information database and makes an inquiry to the aforementioned terminal regarding whether or not to conduct high-speed data communication at said maximum communication speed when said maximum communication speed is a lower speed than the aforementioned requested communication speed.

10. The wireless communication system according to any of Claims 1-9, characterized by the fact that

the central base station conducts wireless transmission of data to the terminal with a predetermined transmission output within the macrocell,

a repeater that receives the wireless signals transmitted from the aforementioned central base station, amplifies said wireless signals, and retransmits to the terminal is provided within the aforementioned macrocell instead of a microcell base station, and the aforementioned terminal receives the wireless signals retransmitted from the aforementioned repeater and conducts high-speed data communication with the aforementioned central base station.

11. A communication control method for a wireless communication system characterized by the fact that a plurality of microcell base stations capable of high-speed data communication in a small area are provided within the macrocell used by a central base station capable of low-speed data communication in a wide area and terminals conduct data communication with the aforementioned central base station or the aforementioned microcell base stations,

a communication speed determination step is included in which it is determined whether or not a higher communication speed than the communication speed for data communication with the aforementioned central base station is needed when a data communication request is received from the aforementioned terminal,

a connection control step is included in which a control signal of high-speed data communication request is sent when it is determined that high-speed communication is needed in the aforementioned communication speed determination step, and

high-speed data communication service providing step is included in which the aforementioned microcell base station uses a microcell to conduct high-speed data communication between the aforementioned terminal and the concerned microcell base station limited only to when a control signal for a high-speed data communication request was transmitted in said connection control step.

12. The communication control method for a wireless communication system of Claim 11, characterized by the fact that a terminal position detection step is included in which the position information of the concerned terminal is detected and the concerned position information is output to the connection control means when it is determined in the communication speed determination step that high-speed communication is needed and

a microcell base station specifying step is included in which it specified which microcell base station is capable of high-speed data communication with the aforementioned terminal based on the aforementioned position information, transmitted in the connection control step, included in the control signal of high-speed data communication request and the respective position information of a plurality of microcell base stations stored in advance, and

in the high-speed data communication service providing step, only the microcell base station specified in the microcell base station specifying step arranges for a microcell to conduct high-speed data communication between the aforementioned terminal and the aforementioned specified microcell base station limited only to when a control signal containing a high-speed data communication request was transmitted in the aforementioned connection control step.

13. The communication control method for a wireless communication system of Claim 11, characterized by the fact that a terminal position estimation means is provided that estimates the position information of the terminal when a control signal containing high-speed data communication request is transmitted in the aforementioned connection control step and

a microcell base station specifying step is included in which it is specified which the microcell base station is capable of high-speed data communication with the aforementioned terminal based on the aforementioned position information and the respective position information of a plurality of microcell base stations stored in advance, and

in the high-speed data communication service providing step, only the microcell base station that was specified in the microcell base station specifying step arranges for a microcell to conduct high-speed data communication between the aforementioned terminal and the aforementioned specified microcell base station limited only to when a control signal containing a high-speed data communication request was transmitted in the aforementioned connection control step.

14. A communication control method for a wireless communication system according to Claim 12 or 13, characterized by the fact that in addition, a quality request determination means is provided that determines whether or not high-speed data communication of favorable communication quality is needed when it is determined that high-speed data communication is needed in the communication speed determination step,

the connection control means transmits a control signal of a high-speed communication request including a high quality communication request when it is determined in the concerned quality request determination step that high-speed data communication of favorable communication quality is needed, and

in the high-speed data communication service providing step the microcell base station specified in the microcell base station specifying step arranges for a microcell, wherein the communication available area has been expanded, to conduct high-speed data communication

between the aforementioned terminal and the aforementioned specified microcell base station when a control signal for a high-speed data communication request containing a high quality communication request was transmitted in the aforementioned connection control step.

15. A communication control method for a wireless communication system of Claim 14, characterized by the fact that in the microcell specifying step, all microcell base stations may be specified within a predetermined area that includes the terminal whereto a control signal of high-speed data communication request was transmitted based on the aforementioned position information transmitted in the connection control step by being included in the control signal of the high-speed data communication request and the respective position information of a plurality of microcell base stations stored in advance when a high quality communication request is included in the control signal for a high-speed data communication request and

in the high-speed data communication service providing step, the aforementioned specified microcell base stations transmit respective data to the aforementioned terminals and conduct high-speed data communication.

16. A management method for a wireless communication system according to Claim 14 or 15, characterized by the fact that a user charge management step is included in which the communication charge for each data communication is calculated by individually tabulating the total communication time of low-speed data communication that the terminal conducted with the central base station, the total communication time of high-speed data communication conducted with the microcell base stations that did not accompany a high quality request, and the total communication time of high-speed data communication that accompanied a high quality request and then multiplying the use fee per unit time that was set separately for each data communication to the aforementioned total communication time of each data communication.

Detailed explanation of the invention

[0001]

Industrial application field

The present invention relates to a wireless communication system for data communication between a terminal and base stations, a communication control method thereof, and a management method.

[0002]

Prior art

The need for high-speed data communication in environments with wireless communication systems is increasingly reinforced by the recent activity in mobile communication. High-speed data communication is realized conventionally by enhancing the

communication speed per communication channel or multiplexing a plurality of communication channels. However, in this method, it is necessary to enhance the transmission power of the wireless communication system according to the enhancement in communication speed.

[0003]

In wireless communication systems that employ CDMA (Code Division Multiple Access) for example, it is possible to enhance the data communication speed by dividing the transmission data into plural groups of data and multiplexing the communication channels using different diffusion codes. However, in this case the signal power transmitted by the base station and the terminal increases in proportion to the aforementioned number of multiplexed communication channels. Also, it is also possible to enhance the communication speed per communication channel by decreasing the diffusion coefficient per each 1 bit of transmission data. However, the diffusion gain decreases as the diffusion coefficient decreases. Therefore, there is a need to enhance the transmission power of the wireless signals transmitted by the base station and the terminal in order to prevent degradation of the SN ratio.

[0004]

On the other hand, suppressing the transmission power on the transmitting side can be considered by providing a high-performance amplifier to the receiving side and receiving wireless signals with large amplification gain. However, the need for miniaturization and decreasing the power consumption is strong in mobile communication terminals and loading an amplifier having a big amplification rate and ideal noise figure (NF) is difficult.

[0005]

Also, an increase in the transmission power with an enhancement in the communication speed for transmission data uses wireless cells of wide area with a radius of a few km and is particularly notable in base stations that accommodate many terminals. For example, even when conducting high-speed data communication with a specific terminal existing in the aforementioned wireless cell, said base station needs to send wireless signals while carrying out amplification to compensate for the propagation loss corresponding to the cell radius (few km) in order to transmit wireless signals everywhere within the wireless cell. In such a case, the transmission power of the wireless signals, after the amplification for compensating for propagation loss, increases even more if the signal power of the base targeted in the transmission has increased with enhancement in the communication speed. There is a limit to this type of increase in the transmission power of the base station due to restrictions in the hardware and can lead to interference with other wireless communication systems.

[0006]

As a method for solving these problems, there is the conventional wireless communication system disclosed in, for example, Japanese Kokai Patent Application No. 2000-23238. Figure 13 is a block diagram showing the aforementioned conventional wireless communication system. Below, the operation of this conventional wireless communication system will be explained according to Figure 13. In this wireless communication system, central base station (103) of large transmission power uses wireless cell (hereafter referred to as macrocell) (104) of wide area having a radius of a few km and terminal (105) capable of communicating with this central base station (103) exists within this macrocell (104). The data communication speed is restricted between the aforementioned central base station (103) and terminal (105) due to a restriction in the transmission power of both and only low-speed data communication is possible in addition to transmission and receiving of audio and control data.

[0007]

On the other hand, another base station (101) is provided in the aforementioned macrocell (104) and wireless cell (hereafter referred to as microcell) (102) of small area having radius of about 100 m is used. Distance (r_A) between this base station (101) and terminal (105) can be estimated to be smaller than distance (r_B) between the aforementioned central base station (103) and terminal (105) and the amplification rate of the wireless signals for compensating propagation loss can be suppressed to a low rate. As a result, the transmission power of the wireless signals of this base station (101) is set to be lower than that of central base station (103) of the aforementioned macrocell.

[0008]

Also, when the terminal transmits signals with the same transmission power, the less propagation loss is communicated to base station (101) of the aforementioned macrocell, wherein the propagation distance is small, hence it is advantageous for high-speed data communication. Maximum communication speed U_{macro} of central base station (103) of a macrocell and maximum communication speed U_{micro} of base station (101) of a microcell are established as

$$U_{micro} > U_{macro}$$

[0009]

The aforementioned base stations (101) and (103) are constantly sent control signals that include the identification information and transmission power value of the concerned base

stations throughout the wireless cells and receive control signals of both base stations (101) and (103) when terminal (105) is within said wireless cells (102) and (104). Terminal (105) calculates the maximum communication speed U_{micro} and U_{macro} of the respective base station, the transmission power of the respective base station, the amount of propagation loss from the respective base station to concerned terminal (105), etc.

[0010]

When a call request for high-speed data communication is sent from terminal (105), terminal (105) selects base station (101) which satisfies the communication speed specified by the call request and the transmission power is the minimum from among base stations (101) and (103) that received the aforementioned control signal and starts communication by connecting to said base station (101).

[0011]

On the other hand, when a call request for audio or low-speed data communication is sent from terminal (105), terminal (105) selects central base station (103) using macrocell (104) as the optimal base station and starts communication by connecting to said central base station (103).

[0012]

Problems to be solved by the invention

In the aforementioned conventional wireless communication system, terminal (105) receives a plurality of control signals constantly from a plurality of base stations (101) and (103) and communicates by specifying the base station that satisfies the communication speed specified in the call request based on the concerned control signal. Therefore, there is the problem of terminal (105) needing to maintain a connection with base station (101) that was specified at a time of the call and not being able to move outside microcell (102) used by said base station when continuing high-speed data communication.

[0013]

Also, if terminal (105) moves outside the aforementioned microcell (102) during high-speed data communication, communication with base station (101) to which it was connected then cannot be maintained. Therefore, there is the problem of needing to receive the control signals of base stations (101) and (103) existing at the periphery and reconnecting by specifying another base station (101) provided in the aforementioned macrocell (104); this type of reconnection process degrades the communication quality.

[0014]

The present invention solves the aforementioned problems and the purpose thereof is to provide a wireless communication system capable of enhancing the mobility of a terminal conducting high-speed data communication while suppressing an increase in the transmission power of the entire wireless communication system accompanies enhanced communication speed.

[0015]

Means to solve the problems

In order to solve the aforementioned problems and to achieve the purpose, the wireless communication system of the present invention is characterized by the fact that it is provided with a central base station that uses macrocells covering a wide communication available area, terminals that are wirelessly connected to the aforementioned central base station to conduct data communication at a low communication speed and has a communication speed determination means that determines whether or not a communication speed that is higher than the communication speed with the aforementioned central base station is needed when a data communication request is received and a connection control means that transmits a control signal of high-speed data communication request when the aforementioned communication speed determination means determines that a higher communication speed is needed, and a microcell base stations that use a microcells whose communication available area is smaller than that of the aforementioned macrocell and establishes a wireless connection to the aforementioned terminal to conduct data communication at a higher speed than that of the central base station limited only to when a control signal containing a high-speed communication request is transmitted from the aforementioned terminal.

[0016]

The wireless communication system of the next invention is characterized by the fact that a plurality of microcell stations are provided in the macrocells and in addition a base station position information database is provided wherein the respective position information of the aforementioned plurality of microcell base stations are recorded in advance, the terminals have a position information generating means that detects the position information of the concerned terminal, the connection control means transmits a control signal of a high-speed data communication request including the aforementioned position information, the aforementioned base station position information database specifies a microcell base station capable of wireless connection with the aforementioned terminal based on the respective position information of the

aforementioned plurality of microcell base stations and the position information of the terminal included in the aforementioned control signal of a high-speed data communication request, and only said specified microcell base station establishes a wireless connection to the aforementioned terminal to conduct high-speed data communication.

[0017]

The wireless communication system of the next invention is characterized by the fact that a plurality of microcell stations are provided in the macrocell and in addition a base station position information database is provided wherein the respective position information of the aforementioned plurality of microcell base stations have been recorded in advance, the central base station has a direction detection means that estimates the incoming direction of the wireless signals transmitted from the terminal requesting high-speed data communication, a reception intensity measurement means that measures the reception intensity of the wireless signals transmitted from the aforementioned terminal, and a terminal position estimating means that estimates the position of the terminal based on the incoming direction and reception intensity of the aforementioned wireless signals, the aforementioned base station position information database specifies a microcell base station capable of wireless connection with the aforementioned terminal based on the respective position information of the aforementioned plurality of microcell base stations and the position information of the terminal estimated by the aforementioned terminal position estimating means, and only the concerned specified microcell base station establishes a wireless connection to the aforementioned terminal to conduct high-speed data communication.

[0018]

The wireless communication system of the next invention according to Claim 2 or 3 is characterized by the fact that the base station position information database is constituted to calculate the maximum communication speed of data communication capable of being used by the terminal based on the position information of said terminal and respond to the aforementioned terminal, and the communication speed determination means is constituted to make an inquiry regarding the communication speed of the usable data communication to the aforementioned base station position information database before starting the data communication and allows the user of said terminal to select the data communication speed used in the data communication based on the aforementioned maximum communication speed of the usable data communication.

[0019]

The wireless communication system of the next invention is characterized by the fact that the terminals are provided with a quality request determination means that determines whether or not high-speed data communication of favorable communication quality is needed when a determination is made that high-speed data communication is needed, the connection control means transmits a control signal of a high-speed communication request including a high quality communication request when said quality request determination means determines that high-speed data communication of favorable communication quality is needed, and the microcell base station specified by the base station position information database expands the concerned microcell according to the aforementioned high quality communication request and conducts high-speed data communication with the aforementioned terminal.

[0020]

The wireless communication system of the next invention is characterized by the fact that the terminals are provided with a quality request determination means that determines whether or not high-speed data communication of favorable communication quality is needed when a determination is made that high-speed data communication is needed, the connection control means transmits a control signal for a high-speed communication request including a high quality communication request when said quality request discriminating means determines that high-speed data communication of favorable communication quality is needed, the base station position information database specifies all microcell base stations in a predetermined area that includes the aforementioned terminal according to the aforementioned high quality communication request, and the pertinent specified microcell base stations transmit the respective data to the aforementioned terminal.

[0021]

The wireless communication system of the next invention is characterized by the fact that the terminals have a moving speed detection means that detects the moving speed of the concerned terminal and the quality request discriminating means can determine that high-speed data communication of favorable communication quality is needed when the aforementioned detected moving speed is greater than a predetermined threshold value.

[0022]

The wireless communication system of the next invention is characterized by the fact that a microcell base station control means is provided that controls a plurality of microcell base stations, the communication speed determination means determines whether or not a higher

communication speed than that of the communication speed between the central base station and the microcell base station is needed when a data communication request is received and when it is determined that a high-speed communication is needed, the connection control means transmits a control signal for a high-speed, large-capacity data communication request to the aforementioned microcell base station control means, and the microcell base station control means that received the concerned control signal transmits multiple transmissions by plural stations of the transmission data with respect to the aforementioned terminal via the plurality of microcell base stations specified according to the base station position information database.

[0023]

The wireless communication system of the next invention is characterized by the fact that the communication control means transmits a control signal for a high-speed, large-capacity data communication request including information related to the requested communication speed, the microcell base station control means that received the concerned control signal calculates the maximum communication speed capable of being provided by the plurality of microcell base stations specified that were according to the base station position information database, and makes an inquiry to the aforementioned terminal regarding whether or not to conduct the high-speed data communication at the concerned maximum communication speed when said maximum communication speed is a lower speed than the aforementioned requested communication speed.

[0024]

The wireless communication system of the next invention is characterized by the fact that the central base station wirelessly transmits data to a terminal with a predetermined transmission output within the macrocell, a repeater is provided that has a receiving antenna and receives wireless signals transmitted from the aforementioned central base station, a low distortion transmission amplifier is provided that amplifies the received signals received with the concerned receiving antenna, and a retransmission antenna is provided that retransmits the received signals to the terminal after amplification, all being provided in the aforementioned macrocell instead of the microcell base station, and the aforementioned terminal receives the wireless signals retransmitted from the aforementioned repeater and conducts high-speed data communication with the aforementioned central base station.

[0025]

The communication control method for a wireless communication system of the next invention is characterized by the fact that a plurality of microcell base stations capable of high-

speed data communication in a small area are provided within the macrocell used by a central base station capable of low-speed data communication in a wide area and terminals conduct data communication with the aforementioned central base station or the aforementioned microcell base stations, with a communication speed determination step included in which it is determined whether or not a higher communication speed than the communication speed of data communication with the aforementioned central base station is needed when a data communication request is received from the aforementioned terminal, a connection control step is included in which a control signal for a high-speed data communication request is transmitted when it is determined that high-speed communication is needed in the aforementioned communication speed determination step, and high-speed data communication service providing step is included in which the aforementioned microcell base station uses a microcell to conduct high-speed data communication between the aforementioned terminal and said microcell base station limited only to when a control signal for high-speed data communication request was transmitted in the concerned connection control step.

[0026]

The communication control method for a wireless communication system of the next invention is characterized by the fact that a terminal position detection step is included in which the position information of the concerned terminal is detected and the concerned position information is output to the connection control means when it is determined in the communication speed determination step that high-speed communication is needed and a microcell base station specifying step is included in which it is specified which microcell base station is capable of high-speed data communication with the aforementioned terminal based on the aforementioned position information, transmitted by being included in the control signal of a high-speed data communication request in the connection control step and the respective position information of a plurality of microcell base stations stored in advance, in the high-speed data communication service providing step, only the microcell base station specified in the microcell base station specifying step arranges for a microcell to conduct a high-speed data communication between the aforementioned terminal and the aforementioned specified microcell base station limited only to when a control signal containing a high-speed data communication request was transmitted in the aforementioned connection control step.

[0027]

The communication control method for a wireless communication system of the next invention is characterized by the fact that a terminal position estimating means is provided that estimates the position information of the terminal when a control signal containing a high-speed

data communication request is transmitted in the aforementioned connection control step and a microcell base station specifying step is included in which it is specified which microcell base station is capable of high-speed data communication with the aforementioned terminal based on the aforementioned terminal position and the respective position information of a plurality of microcell base stations stored in advance, in the high-speed data communication service providing step, only the microcell base station specified in the microcell base station specifying step arranges for a microcell to conduct high-speed data communication between the aforementioned terminal and the aforementioned specified microcell base station limited only to when a control signal containing a high-speed data communication request was transmitted in the aforementioned connection control step.

[0028]

The communication control method for a wireless communication system of the next invention is characterized by the fact that a quality request determination means is provided that determines whether or not high-speed data communication of favorable communication quality is needed when a determination is made that high-speed data communication is needed in the communication speed determination step, the connection control means transmits a control signal of high-speed communication request including a high quality communication request when the concerned quality request determination step determines that high-speed data communication of favorable communication quality is needed, in the high-speed data communication service providing step, the microcell base station specified in the microcell base station specifying step arranges for a microcell, wherein the communication available area has been expanded, to conduct high-speed data communication between the aforementioned terminal and the aforementioned specified microcell base station when a control signal of a high-speed data communication request containing a high quality communication request was transmitted in the aforementioned connection control step.

[0029]

The communication control method for a wireless communication system of the next invention is characterized by the fact that, in the microcell specifying step, all microcell base stations may be specified within a predetermined area that includes the terminal whereto a control signal of a high-speed data communication request was transmitted based on the aforementioned position information transmitted by being included in the control signal of the high-speed data communication request in the connection control step and the respective position information of a plurality of microcell base stations stored in advance when a high quality communication request was included in the control signal of a high-speed data communication

request, in the high-speed data communication service providing step, the aforementioned specified microcell base stations transmit the respective data to the aforementioned terminals and conduct high-speed data communication.

[0030]

A management method for a wireless communication system of the next invention is characterized by the fact that a user charge managing step is included in which the communication charge for each data communication is calculated by individually tabulating the total communication time of low-speed data communication that the terminal conducted with the central base station, the total communication time of high-speed data communication conducted with the microcell base station that did not accompany a high quality request, and the total communication time of high-speed data communication that accompanied a high quality request and then multiplying the use fee per unit time that was set separately for each data communication to the aforementioned total communication time of each data communication.

[0031]

Embodiments of the invention

Application Example 1

Figure 1 is a block diagram of the wireless communication system in Application Example 1 of the present invention. In Figure 1, (1a) and (1b) are the microcell base stations that respectively uses microcells (2) and (2b) and (3) is the central base station that uses macrocell (4). In actuality, many microcell base stations are provided within this macrocell (4) and the microcells are used in phases. However, only two microcell base stations (1a) and (1b) are shown in Figure 1 for simplification.

[0032]

Also, (5) is a terminal for wireless connection and data communication with one of the aforementioned base stations (1a), (1b), and (3), (6) is a communication network to which base stations (1a), (1b), and (3) are connected, (7) is a microcell position information database recorded with the provided position information of all base stations (1a), (1b) and central base station (3), and (8) is a user charge database for monitoring the connected state of terminal (5) to the communication system and recording the charge information with respect to said terminal (5).

[0033]

Below, the operation of a wireless communication system constituted as described above will be explained according to the figure. In the wireless communication system of Application

Example 1, central base station (3) uses macrocell (4) wherein the cell radius is, for example, about 3 km. Terminal (5) can connect to central base station (3) within said macrocell (4) and conduct low-speed audio communication and data communication at communication speeds of up to about 100 Kbit/sec. However, said central base station (3) cannot provide high-speed data communication service of communication speeds greater than, for example, a few M to a few + M bit/sec directly to terminal (5) due to restriction in the transmission power and restrictions in the performance such as the amplification gain, NF, etc. of the amplifier provided in terminal (5).

[0034]

Also, the aforementioned central base station (3) is constantly sent control signals containing identification information of the concerned base station and incoming call information with respect to the terminal and terminal (5) can conduct communication control with respect to central base station (3) such as wireless management and call control by receiving these control signals.

[0035]

On the other hand, a plurality of microcell base stations (1a) and (1b) are provided in the aforementioned macrocell (4) and respectively constitute microcells (2a) and (2b) wherein the cell radius is, for example, about 100 m.

[0036]

Here, propagation loss L_p [dB] in a free space is provided by the following Formula 1.

[Equation 1]

$$L_p = 10\log\left(\frac{4\pi d}{\lambda}\right)^2 \qquad \text{Formula 1}$$

d is the distance [m] between base station-terminal and λ the carrier wavelength [m] of the wireless signal.

[0037]

In the aforementioned formula, if the wireless communication system uses a carrier frequency of, for example, 2 GHz, the maximum estimated propagation loss of said microcells (2a) and (2b) (cell radius 100m) is about 79 dB and the propagation loss is less by about 30 dB compared to the case of aforementioned macrocell (4) (cell radius 3 km), wherein the maximum estimated propagation loss is about 108 dB. The actual propagation loss in urban areas depends on the distance (d) between base station-terminal and it is known to be greater than the

aforementioned propagation loss (Lp) in free spaces and the relative propagation loss difference of the aforementioned macrocell and microcell is then even greater.

[0038]

The base stations need to amplify wireless the signals to be transmitted with a large amplification rate in order to compensate for the aforementioned propagation loss. However, the amplification gain for compensating for the propagation loss can be set low in microcell base stations (1a) and (1b), wherein the propagation loss is small and the communication speed can be enhanced by that much according to channel multiplexing and the like. For example, if the relative propagation loss difference between microcells (2a) and (2b) and macrocell (4) is about 30dB as described above, microcell base stations (1a) and (1b) can enhance the communication speed of transmission data up to about 1000-fold with the same transmission power as central base station (4) by using a method such as multiplexing of the communication channels and the like and can provide high-speed data communication service at communication speeds of about a few M to a few +M bit/second to terminal (5).

[0039]

Next, Figure 2 is a block diagram of terminal (5). In Figure 2, (11) is a communication speed determination part that receives data communication requests from a user application connected to said terminal (5) and determines the necessary communication speed, (12) is a position information generating part that detects the position of said terminal (5), and (13) the connection control part that carries out communication control with the aforementioned base stations (1a), (1b) and (3).

[0040]

Connection control part (13) receives control signals from the aforementioned central base station (3) and carries out communication control processing such as wireless management, movement management, call control, and the like. Also, this connection control part (13) has a communication control processing function with respect to microcell base stations (1a) and (1b) and can connect to microcell base stations (1a) and (1b) concurrent to the communication control processing with respect to the aforementioned central base station (3) or by changing these processes.

[0041]

When a data communication request is generated from a user application, communication speed determination part (11) receives this request and determines the necessary communication

speed. For example, if a transmission request of audio or text data is generated from a user application, the necessary communication speed is determined to be low and outputs this determination result to connection control part (13). Connection control part (13) carries out call connection control with respect to central base station (3) based on this determination result and starts communication control.

[0042]

On the other hand, communication speed determination part (11) determines that the necessary communication speed is high when a transmission request for streaming video data and the like is generated from the aforementioned user application and outputs this determination result to the aforementioned connection control part (13).

[0043]

Next, connection control part (13) that receives the high-speed data communication request makes an inquiry regarding the position information of the concerned terminal to position information generating part (12). This position information generation part (12) is provided with a position information detection function according to GPS, detects the position of terminal (5), and outputs the concerned position information. Next, connection control part (13) generates a control signal for a connection request containing the aforementioned position information and a high-speed data communication request and transmits to central base station (3), while carrying out communication control.

[0044]

Central base station (3) that received the control signal containing a high-speed data communication request from terminal (5) reads the high-speed data communication request and the position information of terminal (5) from this control signal. Next, central base station (3) sends the position information of terminal (5) to base station position information database (7) and makes an inquiry to this base station position information database (7) regarding the microcell base stations capable of providing high-speed data communication service to terminal (5).

[0045]

Figure 3 is an explanatory diagram showing the base station position information regarding terminal 5 stored in the base station position information database (7). In this base station position information database (7), information related to each base station belonging to this wireless communication system, for example, base station identification information, base

station position information, cell radius, transmission power, and compatible communication speeds, are stored.

[0046]

Next, base station position information database (7) calculates the distance between terminal – microcell base station from the position information of the aforementioned terminal and the position information of each microcell base station stored in said database and specifies the microcell base station capable of providing high-speed data communication service. In the example shown in the aforementioned Figure 1, first, all microcell base stations (1a) and (1b) capable of accommodating high-speed communication from among all the base stations recorded in the concerned database are specified. Next, the distance between the aforementioned terminal and microcell base stations (1a) and (1b) are successively calculated and it is verified whether or not the calculated distance is less than the cell radius of the microcells used by said microcell base station. In the example shown in Figure 1, terminal (5) is within microcell (2a) and microcell base station (1a) satisfies the aforementioned conditions. Therefore, said base station position information database (7) specifies microcell base station (1a) as the microcell base station capable of providing high-speed data communication service and this result is notified to central base station (3).

[0047]

Central base station (3) that received this specification result makes a request to microcell base station (1a) to provide high-speed data communication service via communication network (6) and transmits a response indicating that the high-speed data communication service will be provided by microcell base station (1a) to terminal (5) by including the control signal being sent within macrocell (4).

[0048]

Microcell base station (1a) that received the aforementioned request then sends the control signal that includes the base station identification information and the like within microcell (2a). On the other hand, terminal (5) receives the response that high-speed data communication service will be provided transmitted from the aforementioned central base station (3) and recognizes that the high-speed data communication service will be provided by microcell base station (1a) from this response. Next, connection control part (13) of terminal (5) receives the controls signal sent from the aforementioned microcell base station (1a), carries out the communication control process, and starts high-speed data communication.

[0049]

Microcell base station (1a), which started high-speed data communication with terminal (5), informs the aforementioned user charge database (8) that terminal (5) has started high-speed data communication via communication network (6). User charge database (8) records the use start time of high-speed data communication by terminal (5).

[0050]

Also, connection control part (13) of terminal (5) periodically transmits control signals containing position information to central base station (3) even during high-speed data communication with microcell base station (1a). Central base station (3) receives this position information transmitted from terminal (5) and makes an inquiry to the aforementioned base station position information database (7) regarding the microcell base station capable of providing high-speed data communication service.

[0051]

For example, if terminal (5) moves and approaches microcell base station (1b) while connected to the aforementioned microcell base station (1a) and conducting high-speed data communication, microcell base stations (1a) and (1b) are specified as the base stations capable of high-speed data communication service as a result of the inquiry made to base station position information database (7). Next, central base station (3) makes a request to provide high-speed data communication service to said specified microcell base stations (1a) and (1b) via communication network (6).

[0052]

Microcell base station (1b) that received this request establishes a synchronization with microcell base station (1a) already connected to terminal (5) via communication network (6) and starts providing high-speed data communication service to terminal (5). Terminal (5) receives the data signals transmitted from microcell base stations (1a) and (1b), synthesizes them, and continues high-speed data communication.

[0053]

Next, if terminal (5) moves outside of microcell (2a), microcell base station (1a) ceases to be specified as being appropriate for high-speed data communication service with respect to the inquiry made to base station position information database (7) from central base station (3). In this case, central base station (3) instructs microcell base station (1a) to stop providing high-speed data communication service to terminal (5).

[0054]

Next, when the user application ends data communication at terminal (5) conducting high-speed data communication with microcell base station (1b), the aforementioned connection control part (13) terminates the connection to this microcell base station (1b) and continues only the communication control process with respect to central base station (3). On the other hand, microcell base station (1b), which ended the high-speed data communication with terminal (5), notifies the aforementioned user charge database (8) that the high-speed data communication that was being carried out by terminal (5) has ended via communication network (6). User charge database (8) records the use end time of high-speed data communication that was being carried out by terminal (5).

[0055]

Here, use start time and use end time of high-speed data communication carried out by terminal (5) using microcell base stations (1a) and (1b) are recorded in user charge database (8). User charge database (8) calculates the high-speed data communication using time of terminal (5) from said record, multiplies the predetermined use fee per unit time to this time, and calculates the total use fee for the high-speed data communication carried out by terminal (5). The service provider of the concerned wireless communication system charges the user of terminal (5) for the total use fee of said high-speed data communication service.

[0056]

By being constituted as described above, the wireless communication system in this Application Example 1 provides high-speed data communication service from the microcell base stations by providing a plurality of microcells (2a) and (2b) that are used by microcell base stations (1a) and (1b) capable of providing high-speed data communication within macrocell (4) used by central base station (3) and specifying the microcell base station in the vicinity of terminal (5) based on the position information of said terminal (5). Therefore, even if terminal (5) moves, the microcell base station located in the vicinity of said terminal (5) is always specified to provide high-speed data communication service and the mobility of terminal (5) using the high-speed data communication service can be enhanced.

[0057]

Also, the high-speed data communication service is provided only by microcell base stations (1a) and (1b) wherein the cell radius is small and the propagation loss between the terminal and base station is small and low-speed communication such as transmitting and

receiving of audio and test data is carried out only in central base station (3) wherein the cell radius is large and the propagation loss between the terminal and base station is great. Therefore, it is not necessary to conduct high-speed data communication wherein the signal power increases at central base station (3) when the cell radius is large and the propagation loss between terminal (5) is estimated to be large. As a consequence, even if the speed at which data communication service is provided increases, an increase in the transmission power of the entire data communication service can be suppressed.

[0058]

Also, it was constituted for the aforementioned central base station (3) to specify only microcell base stations (1a) and (1b) capable of providing high-speed data communication service to terminal (5), only these specified microcell base stations (1a) and (1b) sent the control signals, and wireless signals are output to terminal (5). As a consequence, it is possible to provide high-speed data communication service by restricting the time and the area within the service area according to the request from terminal (5), effective use of the wireless resource can be achieved in the wireless communication system as a whole, and reducing interference with other wireless communication systems is made possible.

[0059]

Incidentally, in this Application Example 1, the aforementioned microcell base stations (1a) and (1b) and central base station (3) need not provide service to terminal (5) by using the same communication control system and the same frequency and can be constituted to use varying communication control systems and varying frequencies. In such case, communication control with respect to the aforementioned microcell base stations is realized by providing the aforementioned terminal (5) with a multiple mode communication control function conforming to a plurality of communication control systems and changing to the corresponding communication control function that conforms to the base station to be connected or using a plurality of communication control functions concurrently in connection control part 13 (multiple mode communication terminal).

[0060]

Also, position information generation part (12) generated the position information of the concerned terminal (5) with the position information detection function based on GPS in this Application Example 1. However, it is not restricted to this constitution and can be constituted to generate the position information of said terminal (5) according to other position information detection methods.

[0061]

For example, position information generation part (12) stores the received signal level regarding the respective control signals and the base station identification information included in said control signals and outputs the information related to said plurality of control signals as control signal receiving information of the terminal (5) when said terminal (5) can receive controls signals from a plurality of base stations. Central base station (3) sends the control signal receiving information of said terminal (5) to base station position information database (7) and makes an inquiry about the microcell base stations capable of providing high-speed data communication service to terminal (5).

[0062]

Next, base station position information database (7) reads the reception signal level of each control signal from the control signal receiving information of the aforementioned terminal (5), calculates the propagation loss by comparing the aforementioned signal reception level and the transmission power of each base station stored in said database, and estimates the distance between each base station and the aforementioned terminal (5). Furthermore, the aforementioned estimated distance from the aforementioned terminal (5) to each base station and the cell radius of microcells (2a) and (2b) stored in said database are compared, a microcell base station capable of providing high-speed data communication service to the aforementioned terminal (5) is specified, and this information is output to the aforementioned central base station (3). Even in the constitution described above, it is possible to obtain the same effects as Application Example 1.

[0063]

Application Example 2

In Application Example 1 above, terminal (5) transmits the position information to central base station (3) and base station position information database (7) specifies microcell base stations (1a) and (1b) capable of providing high-speed data communication service to terminal (5). However, in this Application Example 2, central base station (3) estimates the position of terminal (5) by detecting the incoming direction of the wireless signals transmitted from terminal (5) and specifies microcell base stations (1a) and (1b) capable of providing high-speed data communication service. This Application Example 2 varies from Application Example 1 above only in the point that central base station (3) has a position estimation function for terminal (5) and the remaining constitution is the same. Therefore, explanation will be omitted by appending the same reference letters and numbers.

[0064]

Figure 4 is a block diagram of the receiving part of central base station (3) in Application Example 2. In Figure 4, (S) is a reference signal, which is a wireless signal for estimating the position that was transmitted from terminal (5), (θ) is the incoming direction of the concerned reference signal (S), (21) is an array antenna consisting of a total of M antenna elements (#1-#M), (22) is an analog-digital converter (hereafter referred to as A/D) that converts received signals output from the aforementioned antenna elements into digital signals, (23) is a direction detection part that estimates incoming direction (θ) of the aforementioned wireless signal (S) based on the output signals of antenna elements output from the aforementioned A/D (22), (24) is a reception intensity measurement part that measures the reception intensity of wireless signal (S), (25) is a terminal position estimation part that estimates the position of the aforementioned terminal (5) from the aforementioned estimated incoming direction (θ) and reception intensity of the wireless signals, (26) is a propagation loss profile recorded in advance with the position information and propagation loss of a plurality of spots within said macrocell (4), and (27) is a base station control part that carries out inquiries regarding the microcell base stations capable of providing high-speed data communication service based on the aforementioned estimated terminal position information.

[0065]

Below, the operation of the wireless communication system in this Application Example 2 constituted as described above will be explained. First of all, central base station (3), which receives a control signal containing a high-speed data communication service request from terminal (5), makes a request to this terminal (5) to transmit a reference signal for estimating the position. Terminal (5), upon receiving this control signal, transmits the reference signal (S) containing the already known data sequence to central base station (3) with a predetermined transmission output according to a predetermined time. The transmission time and transmission output of reference signal (S) are set in advance with values necessary for central base station (3) to carry out position estimation process of terminal (5).

[0066]

Next, central base station (3) receives reference signal (S) of incoming direction (θ) with array antenna (21). The total antenna elements M constituting this array antenna (21) has a varying number of directional patterns; the elements receive the aforementioned reference signal (S), and output the received signal. The received signals output from the antenna elements are converted into digital signals (X_1-X_M) by A/D (22).

[0067]

Received signals (X_1-X_M) of the antenna elements are input to direction detection part (23). This direction detection part (23) estimates incoming direction (θ) of the aforementioned reference signal (S) using the MUSIC (MUltiple SIgnal Classification) algorithm, which is the direction detection algorithm described in, for example, "Multiple Emitter Location and Signal Parameter Estimation," Schmidt, IEEE Trans., AP34, 3, pp.276-280 (1986) based on the concerned received signals (X_1-X_M).

[0068]

Also, reception intensity measurement part (24) is input with received signals (X_1-X_M), measures the received wave intensity of reference signal (S) by calculating the sum of squares of these signals, compares said received wave intensity and the transmission output of reference signal (S) in terminal (5) that was preset as described above, and calculates the propagation loss from the aforementioned terminal (5) to said central base station (3).

[0069]

On the other hand, the position information of each reference spot and propagation loss of reference signal (S) from each spot to said central base station (3) are measured in advance regarding a plurality of reference spots within said macrocell (4) at the design stage of said wireless communication system and these measured results are stored in propagation loss profile (26) of terminal position estimation part (25). As was described above, when incoming direction (θ) of reference signal (S) is estimated by direction detection part (23), said terminal position estimation part (25) extracts only the reference spots at the periphery of incoming direction (θ) from among all the reference spots stored in propagation loss profile (26).

[0070]

Next, terminal position estimation part (25) successively compares the propagation loss from terminal (5) that was calculated in the aforementioned reception intensity measurement part (24) with the propagation loss of the aforementioned extracted plurality of reference spots, specifies the reference spots wherein the difference between the two propagation loss is less than a predetermined threshold value, and estimates the distance of the concerned specified reference spot from central base station (3) as the distance of terminal (5). Here, the aforementioned threshold value of propagation loss difference influences the precision in estimating the distance of terminal (5) and a value small enough for carrying out the position estimation of terminal (5) is decided in advance.

[0071]

On the other hand, if there were no reference spots in the aforementioned extracted plurality of reference spots wherein the propagation loss difference is less than the aforementioned threshold value, two reference spots of propagation loss close to the value of the propagation loss from the aforementioned terminal (5) are specified, and the position of the concerned terminal (5) is estimated by carrying out an interpolation between these specified reference spots. For example, if the estimated propagation loss from terminal (5) is L_{MT} and the propagation loss of the aforementioned specified two reference spots are L_1 and L_2, the estimated position of terminal (5) is obtained with the following formula.

[Number 2]

$$P_{MT} = P_1 + \left(\frac{L_{MT} - L_1}{L_2 - L_1} \right) \cdot P_2$$

Formula 2

P_{MT} is the estimated position vector of the terminal, P_1 and P_2 are the position vectors of the reference spots

[0072]

Next, the estimated position information of terminal (5) is output to base station control part (27). Base station control part (27) sends the concerned estimated position information to base station position information database (7) via the aforementioned communication network (6) and makes an inquiry regarding microcell base stations capable of providing high-speed data communication service to said terminal (5).

[0073]

Also, central base station (3) estimates the current position of terminal (5) based on the wireless signals of said terminal (5), makes an inquiry to the aforementioned base station position information database (7) about said position, and specifies microcell base stations (1a) and (1b) capable of providing high-speed data communication service to said terminal (5) even while terminal (5) is conducting high-speed data communication by connecting to microcell base station (1a) or (1b).

[0074]

By the constitution as described above, central base station (3) specifies microcell base stations (1a) and (1b) capable of providing high-speed data communication service by estimating the current position of terminal (5) based on the incoming direction and propagation loss of the wireless signals from said terminal (5) in the wireless communication system of this Application

Example 2. Therefore, high-speed data communication service can be provided from microcell base stations (1a) and (1b) located in the vicinity of said terminal (5) even if the current position is not detected in terminal (5), a position information generating part necessary for detecting the current position such as GPS and the like need not be loaded in terminal (5), and miniaturization and decrease in power consumption can be achieved.

[0075]

Also, central base station (3) estimates the current position of terminal (5) and specifies microcell base stations (1a) and (1b) even during the time terminal (5) is conducting high-speed data communication. Therefore, even if terminal (5) moves, the microcell base station located in the vicinity of said terminal (5) is always specified to provide high-speed data communication, increase in the transmission power of the entire wireless communication system is suppressed like in Application Example 1 above, and mobility of terminal (5), which is using the high-speed data communication service, can be enhanced.

[0076]

Incidentally, direction detection part (23) estimated the incoming direction (θ) of reference signal (S) transmitted from terminal (5) using the MUSIC algorithm in this Application Example 2. However, it is not restricted to this type of constitution and can be constituted to estimate the aforementioned incoming direction (θ) using the ESPRIT algorithm, which is the direction detection algorithm described in, for example, "ESPRIT Estimation of Signal Parameters via Rotation Invariance Techniques," Roy Kailath, IEEE Trans., ASSP-37, 7, pp.989-995 (198).

[0077]

Also, terminal position estimation part (25) was constituted to specify the two closest reference spots of propagation loss and the size of propagation loss from terminal (5) when there were no reference spots, when the propagation loss difference is less than the predetermined threshold value, and carry out interpolation between these specified reference spots. However, the number of reference spots to be specified is not restricted to two and can be constituted to carry out interpolation by specifying, for example, ≥ 3 of reference spots.

[0078]

Application Example 3

Application Example 1 above constituted microcell base stations (1a) and (1b) to provide high-speed data communication service to terminal (5) by providing a plurality of microcell base

stations (1a) and (1b) within macrocell (4). However, in this Application Example 3, high-speed data communication service is provided to terminal (5) by providing a plurality of repeaters, which amplifies and retransmits the data signal transmitted from central base station (3), within the aforementioned macrocell (4). The wireless communication system in this Application Example 3 varies from Application Example 1 in the point that high-speed data communication service is provided to terminal (5) by using the aforementioned repeaters and the remainder of the constitution is the same. Therefore, explanation will be omitted by appending the same reference letters and numbers.

[0079]

Figure 5 is a block diagram of the wireless communication system in this Application Example 3. In Figure 5, (30a) and (30b) are the repeaters, which receive the wireless signals from the aforementioned central base station (3) and provide high-speed data communication service.

[0080]

Next, the operation of the wireless communication system in this Application Example 3 will be explained. First of all, a plurality of repeaters (30a) and (30b) are provided within the macrocell of central base station (3) and respectively used with microcells (2a) and (2b). In actuality, many repeaters are provided within said macrocell (4) and the respective microcell is used. However, only two repeaters (30a) and (30b) are shown in Figure 4 for simplification.

[0081]

In this wireless communication system, terminal (5) is connected to the aforementioned central base station (3) and repeaters (30a) and (30b) according to, for example, the OFDM (Orthogonal Frequency Division Multiplexing) communication system. This OFDM communication system has the merit of the frequency use efficiency being high and the multi-pass resistance being excellent. In this type of communication system, terminal (5) can receive and demodulate a plurality of wireless signals transmitted concurrently from a plurality of base stations.

[0082]

The aforementioned terminal (5) conducts communication control with respect to the concerned wireless communication system by connecting to central base station (3) and transmitting and receiving control signals. Here, when there is high-speed data communication request from a user application of terminal (5), connection control part (13) of said terminal (5)

transmits control signal C_1 containing the position information of said terminal (5) and high-speed data communication request to the aforementioned central base station (3).

[0083]

Next, central base station (3), which received the aforementioned control signal C_1, transmits the position information of terminal (5) to base station position information database (7) via communication network (6) and makes an inquiry about a repeater capable of providing high-speed data communication service to said terminal (5). When repeater (30a) is specified as a result, central base station (3) carries out wireless connection to said repeater (30a) and transmits control signal C_2 containing the request to provide high-speed data communication service. Repeater (30a), which received said control signal C_2 notifies about the control signal within microcell (2a), the aforementioned terminal (5) receives said control signal, and starts communication control with respect to repeater (30a).

[0084]

Next, terminal (5) makes a connection to repeater (30a) and starts high-speed data communication with central base station (3) via said repeater (30a). First of all, central base station (3) transmits data signal C_3 to terminal (5) at a high communication speed of a few M to a few + M bit/sec. At this time central base station (3) determines transmission power Q_{MT} allocated to one terminal in advance with the following Formula 3 from total transmission power Q_{max} allowed in said central base station (3) and terminal (5) number k, which is estimated when the high-speed data communications service is used within said macrocell (4) and transmits the aforementioned high-speed data signal C_3 to repeater (30a) with said transmission power Q_{MT}.
[Number 3]

$$Q_{MT} = \frac{(Q_{max} - Q_c)}{k} \qquad \text{Formula 3}$$

Q_c is the transmission power of central base station (3) necessary in communication other than in high-speed data communication service. Also, aforementioned terminal number k depends on the cell arrangement of said wireless communication system and an appropriate value is set in advance in the stage of designing the arrangement macrocell (4).

[0085]

Here, the aforementioned transmission power Q_{MT} allocated per one terminal is determined by depending on the transmission power Q_{max} allowed in central base station (3) and decrease in the transmission power per transmission data 1 bit that accompanies enhancement in the wireless communication speed and propagation loss between terminal (5) and central base

station (3) are not considered. Therefore, high-speed data signal C_3 transmitted from said central base station (3) may not be received at terminal (5) at a wave intensity sufficient for conducting high-speed data communication even if it is within macrocell (4). On the other hand, the amplification performance of the receiving amplifier loaded in said terminal (5) is restricted by the constraint to miniaturize and decrease the power consumption of the terminal. Therefore, it is difficult to amplify the aforementioned control signal C_3 that was received at a low reception intensity to signal intensity sufficient for carrying out high-speed data communication while maintaining a favorable SN ratio.

[0086]

Next, repeater (30a), which received a request to provide high-speed data communication service from the aforementioned central base station (3) receives high-speed data signal C_3 transmitted from central base station (3), amplifies this signal C_3, and retransmits to terminal (5), which is carrying out communication control with said repeater (30a). Incidentally, a plurality of repeaters is provided in macrocell (4) in addition to said repeater (30a). However, it is only repeater (30a) which receives a request to provide high-speed data communication service from central base station (3) that retransmission processing of high-speed data signal C_3 is carried out, and other repeaters do not carry out retransmission processing of high-speed data signal C_3 to be transmitted to terminal (5).

[0087]

In the retransmission processing according to repeaters (30a) and (30b), there are cases of transmission occurring in the retransmission signal by the signal (hereafter referred to as retransmission signal) after the amplification, which is to be retransmitted to terminal (5) from the transmission antenna being received in the receiving antenna through wraparound. This causes degradation in the receiving performance of terminal (5). Therefore, wraparound of the transmission signal (hereafter referred to as wraparound signal) from the wireless signal input from said receiving antenna is eliminated in repeaters (30a) and (30b) of this application example.

[0088]

Below, the amplification of high-speed data signal C_3 and retransmission process in repeater (30a) will be explained. Figure 6 is a block diagram of the aforementioned repeaters (30a) and (30b). In Figure 6, (31) is a receiving antenna that receives wireless signals from central base station (3), (32) is an auxiliary antenna that receives the wraparound of transmission signals (hereafter referred to as wraparound signals) of said repeaters (30a) and (30b), (33) is an antenna canceller that eliminates the wraparound signals of large signal level from the received

signals of the aforementioned receiving antenna (31), (36) is a wraparound canceller that eliminates the residual wraparound signals from the received signals wherein wraparound signals of large signal level were eliminated and outputs retransmission signals, (44) is a low distortion transmission amplifier that amplifies the aforementioned retransmission signals, and (45) is a retransmission antenna that transmits the retransmission signals of post amplification.

[0089]

Also, in antenna canceller (33), (34) is a phase · amplitude control part that controls the phase and amplitude of the received signals of the aforementioned auxiliary antenna (32) and (35) is a synthesizer that synthesizes the received signals of the aforementioned receiving antenna (31) and the outputs of the aforementioned phase · amplitude control part (34).

[0090]

Also, in wraparound canceller (36), (37) is a delay time estimation part that estimates the delay time of the wraparound signal component remaining in the synthesized signal output from the aforementioned antenna canceller (33), (38) is a memory that temporarily holds the retransmission signals, (39) is a correlation processing part that calculates the correlation value of the aforementioned synthesized signal and the retransmission signals held in the aforementioned memory (38), (40) is a transmission route estimation part that calculates the transmission route estimated value from the aforementioned correlation value, (41) is a replica generation part that generates an estimated replica of the wraparound signal (hereafter referred to as replica signal) from the aforementioned transmission route estimated value and the retransmission signal held in the aforementioned memory (38), and (43) is a subtractor that subtracts the aforementioned replica signal from the aforementioned received signal and generates a retransmission signal.

[0091]

First of all, high-speed data signal C_3 transmitted from central base station (3) is received by receiving antenna (31). Here, wraparound signal C_{4r} of the signal being retransmitted to terminal (5) by said repeater (30a) is also received by this receiving antenna (31) in addition to signal C_3 that was received directly from the aforementioned central base station (3). This wraparound signal C_{4r} causes oscillation according to the amplification of the high-speed data signal in said repeater (30a) and causes degradation in the characteristics. Therefore, auxiliary antenna (32) wherein the directivity with respect to the aforementioned wraparound signal C_{4r} is greater than that of the aforementioned receiving antenna (31) is provided in repeater (30a) and high-speed data signal C_3 is received by both the aforementioned receiving antenna (31) and this

auxiliary antenna (32). The signals output from both antennas (31) and (32) are input to antenna canceller (33).

[0092]

Next, the received signal of said auxiliary antenna (31 [sic; 32]) is synthesized with the received signal of said receiving antenna (31) in synthesizer (35) after being phase-adjusted with the received signal of the aforementioned receiving antenna (31) in phase · amplitude control part (34). At this time, phase · amplitude control part (34) controls the amplitude and the phase of the received signal of auxiliary antenna (31 [sic; 32]) by minimizing the signal power of synthesized signal y output from synthesizer (35). As a result, the signal level of wraparound signal C_{4r} is suppressed to low in the concerned synthesized signal y.

[0093]

Next, synthesized signal y output from the aforementioned antenna canceller (33) is input to wraparound canceller (36). This wraparound canceller (36) eliminates wraparound signal C_{4r} remaining in the aforementioned synthesized signal y according to the method disclosed in, for example, "Study related to wraparound canceller in ground wave digital SFN relay" (Yamazaki, et al. Technical Report by the Institute of Electronics, Information, and Communications, RCS2000-64, pp. 89-94, 2000-07), and retransmission signal u is output.

[0094]

Next, retransmission signal u output from the aforementioned wraparound canceller (36) is amplified to signal intensity sufficient for providing high-speed data communication service within the concerned microcell (2a) by low distortion transmission amplifier (44). Here, this low distortion transmission amplifier (44) has an amplification performance sufficient for amplifying the retransmission signal u extracted from high-speed data signal C_3, which was transmitted from central base station (3) with the aforementioned transmission power Q_{MT} and the reception intensity had decreased due to receiving propagation loss, to a signal intensity capable of being received by the aforementioned terminal (5) while maintaining a favorable SN ratio. Next, retransmission antenna (45) converts the retransmission signal after the aforementioned amplification into wireless signal and outputs as retransmission signal C_4 of high-speed data to the aforementioned terminal (5).

[0095]

On the other hand, the aforementioned central base station (3) is provided with a high performance receiving amplifier having amplification gain, and NF sufficient for maintaining the

wireless signal from the aforementioned terminal (5) at a communication capable signal level while maintaining a favorable SN ratio directly receives data from terminal (5) and maintains data communication with terminal (5).

[0096]

Also, the aforementioned terminal (5) transmits control signal C_1 containing the current position information to central base station (3) even during high-speed data communication. Central base station (3), which received this control signal C_1, specifies the repeater located in the vicinity of terminal (5) by making an inquiry to base station position information database (7) regarding the position information of said terminal (5). Therefore, even if terminal (5) is moving during the high-speed data communication, a repeater located in the vicinity of terminal (5) is always specified and high-speed data communication can be provided via this repeater.

[0097]

By constituting as described above, the wireless communication system of this Application Example 3 provides high-speed data communication service by only repeater (30a) located at the vicinity of terminal (5) from among the plurality of repeaters (30a) and (30b) provided within macrocell (4) carrying out the retransmission processing of high-speed data signal C_3 that was transmitted from central base station (3). Therefore, use of a microcell capable of high-speed data communication only in the vicinity of the aforementioned terminal (5) is made possible while restricting the transmission power of central base station (3) when providing high-speed data communication service, and increase in the transmission power of the entire wireless communication system that occurs in high-speed data communication can be suppressed.

[0098]

Also, the aforementioned terminal (5) transmits control signal C_1 containing the position information to central base station (3) even during high-speed data communication, and central base station (3) carries out specification of repeaters (30a) and (30b) based on said position information. Therefore, even if terminal (5) has moved, a repeater located in the vicinity of the concerned terminal (5) is always specified to provide high-speed data communication service, and the mobility of terminal (5) using the high-speed data communication service can be enhanced.

[0099]

Furthermore, by having the constitution of the aforementioned repeater (30a) amplifying and retransmitting high-speed data signal C_3 that was transmitted from central base station (3), it

is possible to realize high-speed data communication and miniaturization, and decrease in the power consumption of the terminal can be achieved even if it is an amplifier wherein the amplification performance such as NF and amplification gain are restricted through being compact and has a low power consumption since it is not necessary to amplify the high-speed data signal with a large amplification factor in terminal (5).

[0100]

Incidentally, a case of connecting terminal (5), the aforementioned central base station (3), and repeaters (30a) and (30b) according to the OFDM communication system was explained in this Application Example 4 [sic; 3]. However, the wireless system between the terminal and the base stations is not restricted to this and the same effects can naturally be obtained with other connecting systems. For example, it can be constituted to wirelessly connect terminal (5) and repeaters (30a) and (30b) with the CDMA system and for terminal (5) to apply RAKE synthesis to the wireless signals transmitted respectively from repeaters (30a) and (30b). Also, it can be constituted to apply a predetermined time offset respectively to the wireless signals transmitted from repeaters (30a) and (30b), provide an compatible equalization function to connection control part (13) of terminal (5), and carry out diversity synthesis and receiving with the plurality of wireless signals that contain the aforementioned time offset as multiple pass multiplex signals when wirelessly connecting terminal (5) and repeaters (30a) and (30b) using a single wireless carrier.

[0101]

Application Example 4

In this Application Example 4, terminal (5) requesting high-speed data communication service determines the communication quality to request according to the moving speed of said terminal (5) and notifies central base station (3), and microcell base stations (1a) and (1b) change the size of microcells (2a) and (2b) according to said requested communication quality to provide high-speed data communication service. This Application Example 4 varies from Application Example 1 only in the point that microcell base stations (1a) and (1b) change the size of the microcells according to the communication quality requested by terminal (5), and the remainder of the operation is the same. Therefore, only the operation of changing the size of microcells carried out by microcell base stations (1a) and (1b) will be explained below, and explanation of the same constitution will be omitted by appending the same reference letters and numbers.

[0102]

Here, "communication quality" as referred to in this application example indicates the quality of data communication that varies according to the frequency at which the base stations are changed for terminal (5). When terminal (5) moves during high-speed data communication, there is a need to maintain the communication by changing a plurality of microcell base stations. The wireless connection is temporarily disconnected and continuity in the data communication is lost before and after changing the base stations. Therefore, the aforementioned communication quality degrades when the frequency of changing the base stations is high, while, on the other hand, the aforementioned communication quality becomes favorable when the frequency of changing the base stations is low.

[0103]

Generally, the aforementioned base station changing frequency varies depending on the area of the wireless cell of the base station whereto terminal (5) is connected and the moving speed of said terminal (5). Namely, when the moving speed of terminal (5) is fixed during data communication, the base station changing frequency becomes low with larger areas of wireless cells and can enhance the aforementioned communication quality as a result. On the other hand, when the area of wireless cell is fixed, the base station changing frequency becomes higher and the communication quality decreases with faster moving speeds of the terminal.

[0104]

Next, Figure 7 is a block diagram of the wireless communication system in Application Example 4. In Figure 7, (50a) is the expanded microcell used by microcell base station (1a). Also, Figure 8 is a block diagram of terminal (5) in this Application Example 4. In Figure 8, (51) is the quality request determination part that determines the size of the requesting cell radius when carrying out high-speed data communication, and (52), the moving speed detection part that detects the moving speed of said terminal (5).

[0105]

Next, the operation of the wireless communication system in this Application Example 4 will be explained. In this Application Example 4, microcell base stations (1a) and (1b) can change and use microcells (2a) and (2b) of normal cell radius and microcell (50a) of expanded cell radius by changing the transmission power of the signal. Incidentally, only expanded microcell (50a) used by microcell base station (1a) was shown in Figure 7 for simplification. However, even microcell base station (1b) can similarly use an expanded microcell by similarly changing the transmission power. Also, only microcell base stations (1a) and (1b) are shown in

Figure 7. However, in actuality, a plurality of other microcell base stations are provided in macrocell (4), and the respective microcell base station can provide high-speed data communication service by changing the cell radius of the microcells.

[0106]

When communication speed determination part (11) determines that high-speed data communication is needed in terminal (5), connection control part (13) obtains the current position information of said terminal (5) from position information generation part (12) as was described above and makes an inquiry to the aforementioned quality request determination part (51) regarding whether or not it is necessary to make a request that an expanded microcell be used in order to maintain the high-speed data communication. Incidentally, a request for expanded microcell will be referred to hereafter as a "high quality communication request."

[0107]

Next, quality determination part (51), which received the aforementioned inquiry, detects the moving speed of said terminal via the aforementioned moving speed detection part (52). For example, if said terminal (5) is mounted to an automobile, said moving speed detection part (52) is connected to the speedometer of the automobile and notifies the detected value of said speedometer to quality request determination part (51) as the moving speed of said terminal (5).

[0108]

On the other hand, a moving speed threshold value is stored in advance in the aforementioned quality determination part (51) in order to determine whether or not high quality communication request is necessary. When terminal (5) moves at a high-speed during high-speed data communication, it is preferable to expand the area of the aforementioned microcell and reduce the base station changing frequency as much as possible. Therefore, quality request determination part (51), which received the notification of moving speed, compares said moving speed with the aforementioned threshold value and determines whether or not it is necessary to request high quality communication from said wireless communication system. For example, if the threshold value of the moving speed where a high quality request is necessary is set at a speed of 20 Km/h and the moving speed of said terminal (5) notified from the aforementioned moving speed detection part (52) is 30 Km/h, quality request determination part (51) determines that said terminal (5) is moving at a high-speed and sends a high quality communication request to the aforementioned connection control part (13). On the other hand, if terminal (5) is stopped or moving at a low-speed and the moving speed of said terminal (5) is lower than the aforementioned threshold value (speed per hour 20 Km/h), said quality request determination

part (51) does not send a high quality communication request to connection control part (13). Below, a case wherein a high quality communication request is generated from quality request determination part (51) will be explained.

[0109]

Next, connection control part (13) generates a control signal containing high-speed data communication service request, position information of the aforementioned terminal (5), and high quality communication request and transmits to central base station (3). Next, central base station (3) makes an inquiry to base station position information database (7) regarding the position information of the aforementioned terminal (5) via communication network (6) and specifies microcell base station (1a), which is capable of providing high-speed data communication service to said terminal (5).

[0110]

Next, central base station (3) makes a request for high quality communication that was transmitted from connection control part (13) of the aforementioned terminal (5) and a request to provide high-speed data communication service to the aforementioned specified microcell base station (1a). Microcell base station (1a), which received said requests, increases the transmission power to be greater than that provided during a normal high-speed data communication service and starts the notification of this control signal within expanded microcell (50a). Also, said microcell base station (1a) transmits the cell radius of the expanded microcell base station (50a) and the increased transmission power to base station position information database (7) via communication network (6) and updates the information related to microcell base station (1a) shown in the aforementioned Figure 3.

[0111]

Next, terminal (5) receives the control signal transmitted from the aforementioned microcell base station (1a), carries out communication control with respect to said microcell base station (1a), and starts high-speed data communication. Here, if the high-speed data communication with terminal (5) is to be carried out while moving, the time connection with said microcell base station (1a) can be maintained is longer than in the normal microcell (2a) since microcell base station (1a) has used expanded microcell (50a). Therefore, the frequency of base station changing during high-speed data communication by mobile terminal (5) is decreased, and the communication quality of high-speed data communication is enhanced.

[0112]

On the other hand, microcell base station (1a) transmits a notification to user charge database (8) indicating that expanded microcell (50a) has started to provide high-speed data communication service to terminal (5) via communication network (6). The start time of high-quality high-speed data communication by said terminal (5) is recorded in said user charge database (8).

[0113]

Figure 9 is an explanatory diagram showing an example of a recording in user charge database (8). The communication start time and communication end time of terminal (5) connected to said wireless communication system are recorded in user charge database (8) by being classified according to the service used. For example, in Figure 9, communication time of terminal (5) is classified into 3 services, which are "low-speed communication" wherein audio or low-speed data communication was carried out with central base station (3), "high-speed communication" wherein high-speed data communication was carried out within normal microcells (2a) and (2b) of microcell base stations (1a) and (1b), and "high quality · high-speed communication" wherein high-speed data communication was carried out within the aforementioned expanded microcell (50a) and the respective communication start/end times are recorded.

[0114]

Also, connection control part (13) of terminal (5) periodically transmits control signals containing high quality communication request and position information to the aforementioned central base station (3) even during a high quality high-speed communication with microcell base station (1a). Said central base station (3) receives said position information transmitted from terminal (5) and makes an inquiry to the aforementioned base station position information database (7) regarding the microcell base station capable of providing high-speed data communication service. The expanded cell radius of said microcell (50a) and the increased transmission power of said microcell base station (1a) are reflected in the information related to microcell base station (1a), which is using expanded microcell (50a), specification of microcell base station is carried out at this time upon giving consideration to the fact that said expanded microcell (50a) is in use, and microcell base station (1a) is specified as the microcell base station capable of providing high-speed data communication service during the time terminal (5) exists within said expanded microcell (50a). Furthermore, if terminal (5) continues to move and has moved outside of the aforementioned expanded microcell (50a), the aforementioned central base station (3) and base station position information database (7) specify another microcell base

station and transmits a request to provide high-speed data communication service that accompanies the aforementioned high quality communication request.

[0115]

Next, when terminal (5) ends high-speed data communication, the aforementioned microcell base station (1a) transmits a notification that use of high quality high-speed communication service by terminal (5) has ended to user charge database (8) via communication network (6). The end time of high quality high-speed communication by said terminal (5) is recorded in user charge database (8). Also, said microcell base station (1a) stops sending wireless signals and resets the information related to said microcell base station (1a) recorded in the aforementioned base station position information database (7) to the cell radius and transmission power of normal microcell (2a).

[0116]

The aforementioned user charge database (8) tabulates the respective total communication time for the respective service based on the recorded communication start/end times for each of the aforementioned services. Furthermore, a predetermined use fee per unit time is multiplied to the total communication time of the respective service and the communication fee for said terminal (5) is calculated. For example, in the example of the recording in user charge database (8) shown in the aforementioned Figure 9, the use fee per unit time that varies for each service is recorded in advance, said in user charge database (8) multiplies the aforementioned calculated communication time and the use fee per unit time separately for each of the aforementioned services, and successively calculates the communication fee for the respective communication service. The service provider of said wireless communication system charges the total amount of communication fee for the services to the user of terminal (5). By setting the use fee per unit time that varies for each service as described above, a communication fee complying with the details of the services that were used are charged to the user of the terminal.

[0117]

A case wherein high quality communication request is generated from quality request determination part (51) of terminal (5) was explained above. However, if terminal (5) is moving at a low-speed and the aforementioned quality request determination part (51) did not generate a high quality communication request, microcell base stations (1a) and (1b) use microcells (20a) and (20b) of normal cell radius and provide high-speed data communication service to the aforementioned terminal (5) in the same manner as in Application Example 1.

[0118]

By constituting as described above, the wireless communication system of this Application Example 4 provides high-speed data communication service to the aforementioned terminal (5) by microcell base stations (1a) and (1b) using expanded microcell (50a) when terminal (5) that is using the high-speed data communication service generates a high quality communication request as a result of the determination carried out on whether or not there is a need to make a high quality communication request. Therefore, in cases wherein there is an anticipation for high frequency of base station changing and degradation in the quality of high-speed data communication in microcells (2a) and (2b) of small cell radius such as when the terminal is moving at a high-speed, high-speed data communication can be provided with expanded microcells (50a) and the mobility of the terminal using high-speed data communication can be enhanced.

[0119]

Also, only microcell base station (1a) located in the vicinity of the terminal (5) uses expanded microcells (50a) and provides high-speed data communication service limited only to a case wherein a request for high-speed data communication service that accompanies the aforementioned high quality communication request was generated from said terminal (5) and if the aforementioned terminal (5) is, for example, at a stop or moving at a low-speed and degradation in the quality of high quality communication that occurs with changing of microcell base stations (1a) and (1b) does not pose a problem, high-speed data communication service is provided with microcells (2a) and (2b) of small cell radius. Therefore, it is possible to suppress the increase in transmission power of microcell base stations (1a) and (1b) that occurs when providing a high-quality high-speed data communication service and the transmission power of the entire wireless communication system can be decreased.

[0120]

Also, user charge database (8) calculates the total communication time of terminal (5) separately for each service provided by said wireless communication system. Therefore, the use fee to be charged to the user can be calculated according to the total communication time of the respective service and the convenience in managing the charges for the terminals belonging to said wireless communication system can be enhanced.

[0121]

Incidentally, in this Application Example 4, microcell base stations (1a) and (1b) provide high-speed data communication service by using expanded microcell (50a) in addition to normal microcells (2a) and (2b). However, the cell radius of the microcells in not restricted to the aforementioned two kinds and microcell base stations (1a) and (1b) may use 3 or more kinds of microcells of varying cell radius. In such case, information that specifies the type of cell radius is transmitted in response to the high quality communication request transmitted from terminal (5) and microcell base stations (1a) and (1b) change the cell radius of the microcells according to said information.

[0122]

Also, in this Application Example 4, position information is generated in terminal (5) requesting the high-speed data communication service and microcell base stations (1a) and (1b) located in the vicinity of said terminal (5) were specified based on said position information. However, the method of specifying the microcell base stations is not restricted to this and can be a constitution wherein the position of said terminal (5) is estimated in central base station (3) and microcell base stations (1a) and (1b) are specified based on the result of said estimation as described in, for example, Application Example 2.

[0123]

Also, in this Application Example 4, moving speed detection part (52) of terminal (5) detects the moving speed by being connected to the speedometer of the automobile or the like. However, it is not restricted to this and, for example, the moving speed of said terminal (5) may be estimated by calculating the time differential value of the position information detected by the aforementioned position information generation part (12).

[0124]

Furthermore, quality request determination part (51) of the aforementioned terminal (5) determines whether or not high quality communication request is necessary according to the moving speed detected by the aforementioned moving speed detection part (52). However, it is not restricted to this method and can be other methods that determine whether or not using a high quality high-speed data communication service is favorable according to expanded microcell (50a). For example, it can be a method wherein the aforementioned quality request determination part (51) determines that high quality communication request is necessary when there is a specific request from the user of said terminal (5).

[0125]

Also, the aforementioned user charge database (8) calculates the use fee to be charged to the user based on the total use time for each service. However, use fee calculation method is not restricted to this and the amount of data transacted between terminal (5) and base stations (1a), (1b), and (3) may be recorded, followed by calculating the total amount, and calculating the use fee to be charged to the user according to the total amount of data for each service that was calculated.

[0126]

Application Example 5

In Application Example 4, high-speed data communication service is provided by microcell base stations (1a) and (1b) using expanded microcell (50a) according to a request from terminal (5). However, in this Application Example 5, the microcell base stations existing within a predetermined distance from said terminal (5) are specified and the high-speed data communication service is provided from all the microcell base stations that were specified, limited only to cases wherein request for high-speed data communication service that accompanies high quality communication request was generated from terminal (5).

[0127]

Incidentally, the wireless communication system in this Application Example 5 varies from Application Example 4 only in the point that the high-speed data communication service is provided from all the microcell base stations within a predetermined distance from the aforementioned terminal (5), and the remainder of the communication control method is the same. Therefore, only the method for specifying the microcell base stations and the method for providing the high-speed data communication service will be explained below and explanation regarding the remainder of the communication control method will be omitted. Also, explanation of the constitution identical to Application Example 4 will be omitted by appending the same reference letters and numbers.

[0128]

Figure 10 is an explanatory diagram showing how the high-speed data communication service is provided according to the microcell base stations in the wireless communication system of this Application Example 5. In Figure 10, (1a)-(1e) are microcell base stations that provide high-speed data communication service, (2a)-(2e) are microcells used by the aforementioned microcell base stations (1a)-(1e), and (55) is the area of a predetermined distance from terminal (5).

[0129]

Next, the method for providing the high-speed data communication service in this Application Example 5 will be explained according to Figure 10. First of all, the aforementioned central base station (3) (not shown in Figure 10), which received the control signal of connection request containing high-speed data communication request, high quality communication request, and position information from terminal (5), reads the aforementioned high quality communication request and position information and transmits to base station position information database (7) (not shown in Figure 10) via communication network (6).

[0130]

On the other hand, distance (R) for regulating peripheral area (55) of the aforementioned terminal (5) to be considered in specifying the microcell base station when a high-speed data communication request that accompanies high quality communication request is generated is stored in advance in the aforementioned base station position information database (7). Said base station position information database (7), which received the high quality communication request and position information of terminal (5) from the aforementioned central base station (3) specifies all microcell base stations within the aforementioned distance (R) from said terminal (5) based on the position information of said terminal (5) and the position information of all microcell base stations stored in said database. For example, if terminal (5) is in spot X in Figure 10(1), all microcell base stations (1a)-(1d) included inside area (55) of distance (R) from said spot X are specified. All microcell base stations (1a)-(1d) that were specified thus are notified to the aforementioned central base station (3) via communication network (6).

[0131]

Here, distance (R) that regulates the aforementioned peripheral area (55) is set to be large enough for terminal (5), which is moving at a high speed, to maintain the communication quality in the high-speed data communication by being measured in advance and is stored in the aforementioned base station position information database (7). For example, if high-speed data communication service is provided to terminal (5), which is moving at a high speed, according to microcell base stations (1a)-(1e) when the cell radius of microcells (2a)-(2e) is about 100 m, changing process between the microcell base stations occurs frequently and the communication quality of high speed data communication degrades. Therefore, sufficient distance (R) is measured in advance according to testing and simulation in order to be sufficiently greater than the cell radius of the aforementioned microcells (2a)-(2e) and for terminal (5), which is moving at a high-speed, to maintain the communication quality in the high-speed data communication.

As a result of this measurement, all microcell base stations within area (55) of distance (R) (=1 km) with said terminal (5) as the center are specified if distance (R) is set at, for example, 1 km.

[0132]

Next, central base station (3) makes a request to all the aforementioned specified microcell base stations (1a)-(1d) to provide high-speed data communication service to terminal (5). Microcell base stations (1a)-(1d), which received said request respectively starts notifying about the control signal to respective microcells (2a)-(2d) after establishing a synchronization between the microcell base stations via the aforementioned communication network (6). Terminal (5) receives the control signal transmitted from the aforementioned microcell base stations (1a)-(1d), carries out communication control processes such as establishing synchronization, wireless control, and the like, and starts the high-speed data communication.

[0133]

The aforementioned specified microcell base stations (1a)-(1d) respectively transmit high-speed data signals to terminal (5) while maintaining synchronization mutually between microcell base stations during the high-speed data communication. The high-speed data signals transmitted respectively from microcell base stations (1a)-(1d) are received and synthesized. For example, when said terminal (5) is connected to the microcell base stations according to the CDMA system, the aforementioned specified microcell base stations (1a)-(1d) transmit the high-speed data signals that were diffused with the same diffusion code to terminal (5) while maintaining synchronization between the base stations. The plurality of high-speed data signals transmitted from the microcell base stations are received in terminal (5), and RAKE synthesis is applied.

[0134]

Also, terminal (5) transmits a control signal containing the position information of said terminal and high quality communication request to the aforementioned central base station (3) even during the time high-speed data communication is being carried out with the aforementioned microcell base stations (1a)-(1d). For example, terminal (5) transmits a control signal containing the position information of moving destination spot Y and the aforementioned high quality communication request to the aforementioned central base station (3) when terminal (5) moves to spot Y from spot X during the high-speed data communication as shown in Figure 10(2).

[0135]

Central base station (3) that received said control signal transmits the aforementioned position information of spot Y, which is the moving destination of terminal (5) and high quality communication request to the aforementioned base station position information database (7). Base station position information database (7), which received this information, newly regulates area (55) regarding the aforementioned spot Y, specifies microcell base stations (1c)-(1e) existing within said area (55), and notifies this to the aforementioned central base station (3). Next, central base station (3) makes a request to the newly specified microcell base stations (1e) to provide high-speed data communication service based on said notification and instructs microcell base stations (1a) and (1b) which were not selected according to the aforementioned base station position information database (7) to stop providing the high-speed data communication service.

[0136]

Next, microcell base station (1e) receiving a new request to provide high-speed data communication service establishes synchronization with microcell base stations (1c) and (1d) that are already providing high-speed data communication service and starts transmitting high-speed data signals to terminal (5). The high-speed data signals that were transmitted from newly specified microcell base stations (1c)-(1e) are received by terminal (5) and synthesized.

[0137]

The aforementioned microcell base station selection process and high-speed data communication service providing method are applied only when high quality communication request is included in the high-speed data communication request generated from the aforementioned terminal (5). On the other hand, if the aforementioned terminal (5) is at a stop or moving at a low-speed and high quality communication request is not included in the high-speed data communication request generated from said terminal (5), the microcell base stations capable of providing high-speed data communication service to said terminal (5) are specified based on the position information of said terminal (5) and the position information of microcell base stations (1a)-(1e) stored in the aforementioned base station position information database (7) and high-speed data communication service is provided only according to said specified microcell base stations.

[0138]

By constituting as described above, the wireless communication system in this Application Example 5 can maintain the communication quality in high-speed data

communication even if terminal (5) moves at a high speed and the mobility of terminal (5) using the high-speed data communication service can be enhanced due to having been constituted to transmit high-speed data signals respectively from all the microcell base stations within a predetermined area (55) wherein said terminal (5) is included and receive and synthesize these signals in terminal (5) when high-speed data communication request that accompanies high quality communication request was generated from terminal (5).

[0139]

Also, when high-speed data signals are transmitted respectively from all the microcell base stations within a predetermined area (55) wherein said terminal (5) is included and a request for high-speed data communication service that does not accompany high quality communication request is generated, the high-speed data communication service is provided only by the microcell base stations capable of providing high-speed data communication service to said terminal (5), limited only to a case when a request for high-speed data communication service that includes high quality communication request is generated from the aforementioned terminal (5). Therefore, increase in the transmission power of the entire wireless communication system that occurs when providing high quality high-speed data communication service can be suppressed.

[0140]

Incidentally, in this Application Example 5, position information is generated in terminal (5) requesting the high quality high-speed data communication service and all the microcell base stations within a predetermined area (55) wherein said terminal (5) is included are specified based on said position information. However, the method for specifying the microcell base stations is not restricted to this, and the position of said terminal (5) in central base station (3) may be estimated and all the microcell base stations within a predetermined area (55) may be specified, where said terminal (5) is included based on the result of said estimation as described, for example, in Application Example 2.

[0141]

Also, in this Application Example 5, a value specified as a result of having measured in advance according to testing or simulation is stored in base station position information database (7) as distance (R) that regulates peripheral area (55) of the aforementioned terminal (5). However, it is not restricted to this constitution and, for example, terminal (5) may determine the extent of distance (R) according to the moving speed of the terminal (5) and transmit a control signal of high-speed data communication request to central base station (3) by including said

distance (R) when requesting a high data communication, said central base station (3) reading this information and transmitting it to the aforementioned base station position information database (7), and said base station position information database (7) specifying all the microcell base stations within area (55) regulated by distance (R) determined in the aforementioned terminal (5). In this type of constitution, the size of area (55) regulated by the aforementioned distance (R) can be changed according to the moving speed of the terminal. Therefore, if, for example, the moving speed of terminal (5) is great, it is possible to maintain the communication quality in high-speed data communication when moving at a high speed by setting distance (R) to be great and increasing the number of microcell base stations providing the high-speed data communication service.

[0142]

Also, in this Application Example 5, a case wherein the aforementioned terminal (5) is connected to microcell base stations (1a)-(1e) according to the CDMA system is shown. However, the method for connecting terminal (5) and microcell base stations (1a)-(1e) is not restricted to the CDMA system and the same effect can naturally be obtained with other connecting systems. For example, even if it is constituted for microcell base stations (1a)-(1e) to respectively transmit high-speed data signals to terminal (5) at respectively varying TDMA slot timing and for terminal (5) to receive and synthesize these high-speed data signals at the respective TDMA slot timing when terminal (5) and microcell base stations (1a)-(1e) are connected with the TDMA system, the same effects as Application Example 5 can be obtained.

[0143]

Application Example 6

In this Application Example 6, a plurality of microcell base stations (1a)-(1c) located in the vicinity of terminal (5) carries out bulk transmission of high-speed large-capacity data to terminal (5), terminal (5) receives the data signals transmitted respectively from the aforementioned microcell base stations (1a)-(1c), and synthesizes them to carry out high-speed, large-capacity data when terminal (5) needs to carry out data communication of larger capacity at a higher speed than that of the high-speed data communication service provided from one base station from among the aforementioned microcell base stations. Below, high-speed bulk transmission of large-capacity data according to said plurality of microcell base stations will be referred to as "plural stations multiple transmissions." Incidentally, the wireless communication system of this Application Example 6 varies from Application Example 5 only in the point that high-speed large-capacity data communication is carried out between microcell base stations (1a)-(1c) and terminal (5). Therefore, only the high-speed large-capacity data communication

method in said wireless communication system will be explained below. Also, explanation of the same constitution as Application Example 5 will be omitted by appending the same reference letters and numbers.

[0144]

Figure 11 is a block diagram of the wireless communication system in this Application Example 6. In Figure 11, (60) is a microcell base station controller that controls microcell base stations (1a)-(1c) and carries out high-speed large-capacity data communication with terminal (5).

[0145]

Next, the operation of the wireless communication system in this Application Example 6 will be explained. First of all, when a request for data communication is generated from a user application in terminal (5), communication speed determination part (11) makes an inquiry to said user application regarding whether it is requesting the low-speed data communication service provided by the aforementioned central base station (3), requesting the high-speed data communication service provided by microcell base stations (1a)-(1c), or needs large-capacity data communication at a higher speed than that of these data communication services.

[0146]

If there is a request for low-speed data communication service from the user application in response to said inquiry, connection control part (13) establishes a wireless connection to central base station (3) according to the aforementioned method and starts a low-speed data communication. Also, when there is a request for high-speed data communication service, the communication control part establishes a wireless connection with microcell base stations (1a)-(1c) located in the vicinity of said terminal (5) according to the aforementioned method and starts high-speed data communication.

[0147]

Next, when there is a request from the aforementioned user application for large-capacity data communication at a speed higher than that of the high-speed data communication service provided by microcell base stations (1a)-(1c), connection control part (13) transmits a control signal request for high-speed large-capacity data communication to the aforementioned central base station (3). At this time, the requested data communication speed is specifically indicated from the aforementioned user application, and a control signal request for high-speed large-capacity data communication is transmitted with the information indicating the requested data communication speed included. Next, central base station (3) transmits the control signal

requesting said high-speed large-capacity data communication to microcell base station controller (60) via communication network (6).

[0148]

Next, microcell base station controller (60), which received said control signal requesting said high-speed large-capacity data communication, makes a request to the aforementioned base station position information database (7) to specify the microcell base stations capable of providing high-speed data communication service to the aforementioned terminal (5). Figure 12 is an explanatory diagram showing how the high-speed large-capacity data communication service is provided in the wireless communication system of Application Example 6. For example, if microcell base stations (1a)-(1c) exist in the vicinity of terminal (5) as shown in this Figure 12, the base station position information database responds to the aforementioned microcell base station controller (60) by specifying these microcell base stations. Also, if microcell base stations (1a)-(1c) can use microcells (50a)-(50c) that were expanded as described above, base station position information database (7) specifies the microcell base stations by giving consideration also to the cell radius of these microcells.

[0149]

Next, microcell base station controller (60) makes respective inquiries to the aforementioned specified microcell base stations (1a)-(1c) on whether high-speed data communication service can be provided. If microcell base stations (1a)-(1c) cannot provide high-speed data communication service to terminal (5), for example, it is already providing high-speed data communication service to another terminal (not shown in Figure 11 and Figure 12) or the like, a response to that effect is given to the aforementioned microcell base station controller (60). On the other hand, if microcell base stations (1a)-(1c) can provide high-speed data communication service to terminal (5), a response to that effect is given to the aforementioned microcell base station controller (60).

[0150]

Microcell base station controller (60), which received the response from microcell base stations (1a)-(1c) that they can or cannot provide high-speed data communication service, calculates the total sum of the communication speed of microcell base stations (1a)-(1c) capable of providing high-speed data communication service. For example, if the respective microcell base station can provide high-speed data communication service of 20 Mbit/sec with respect to one terminal in said wireless communication system and the number of microcell base stations capable of providing the service are three, namely, microcell base stations (1a)-(1c), the

maximum communication speed of high-speed large-capacity data communication service capable of being provided to terminal (5) according to plural station multiple transmission using these microcell base stations (1a)-(1c) is 60 Mbit/sec. At this time, if there is a microcell base station that cannot provide high-speed data communication service from among the aforementioned microcell base stations (1a)-(1c), microcell base station controller (60) excludes the communication speed of the microcell base station not capable of providing said service and calculates the total sum of the communication speed.

[0151]

Next, microcell base station controller (60) compares the requested data communication speed transmitted from the aforementioned terminal (5) to the aforementioned maximum communication speed capable of being provided (60 Mbit/sec), and if the maximum communication speed capable of being provided is greater than the required data communication speed, a control signal containing information that high-speed large-capacity data communication service can be provided and specifying microcell base stations (1a)-(1c) as the microcell base stations providing said service is transmitted to terminal (5) via communication network (6) and central base station (3). Connection control part (13) of terminal (5) receives said control signal and starts the communication control process with the aforementioned microcell base stations (1a)-(1c).

[0152]

Also, microcell base station controller (60) makes a request to the aforementioned microcell base stations (1a)-(1c) to provide data communication service to terminal (5) with plural station multiple transmission. Microcell base stations (1a)-(1c), which received said request, establish mutual synchronization via communication network (6) and start the control signal notification in expanded microcells (50a)-(50c) as shown in Figure 12.

[0153]

Next, when wireless connection is established between terminal (5) and microcell base stations (1a)-(1c), microcell base station controller (60) divides the large-capacity data for terminal (5) and transmits it to microcell base stations (1a)-(1c). Microcell base stations (1a)-(1c) respectively transmit the aforementioned divided data within expanded microcells (50a)-(50b) while securing the already established mutual synchronization among microcell base stations.

[0154]

Next, terminal (5) receives and synthesizes all the data signals transmitted respectively from the aforementioned microcell base stations (1a)-(1c). For example, if said terminal (5) and microcell base stations (1a)-(1c) are carrying out communication according to the CDMA system, terminal (5) obtains the large-capacity data from before the division by carrying out RAKE synthesis to the plural data signals transmitted respectively from microcell base stations (1a)-(1c).

[0155]

Also, microcell base station controller (60) notifies the start/end of use of the high-speed large-capacity data communication service by terminal (5) and the communication speed of the data communication service used by said terminal (5) to user charge database (8) via communication network (6) and said user charge database (8) records said service use start/end and communication speed and calculates the communication fee for said high-speed large-capacity data communication service.

[0156]

On the other hand, if the result of having compared the requested data communication speed transmitted from terminal (5) to the aforementioned maximum communication speed capable of being provided (60 Mbit/sec) is that the maximum communication speed capable of being provided is less than the requested data communication speed, microcell base station controller (60) transmits a control signal containing information to the fact that it is not possible to provide data communication service at the requested communication speed and indicating the maximum communication speed capable of being provided to terminal (5) via communication network (6) and central base station (3). Next, communication speed determination part (11) in terminal (5) makes an inquiry to the user application that generated the data communication request regarding whether or not it will carry out the data communication at the aforementioned maximum communication speed capable of being provided.

[0157]

If the result is a request to use the high-speed large-capacity data communication service at the aforementioned maximum communication speed capable of being provided, connection control part (13) transmits a control signal indicating that said high-speed large-capacity data communication service will be used to microcell base station (60) via central base station (3) and communication network (6) and plural station multiple transmission high-speed large-capacity data communication according to is carried out between the terminal and microcell base stations (1a)-(1c) according to the aforementioned method.

[0158]

On the other hand, if communication speed determination part (11) receives a response from the aforementioned user application of terminal (5) indicating that it will not request data communication at the aforementioned maximum communication speed capable of being provided, connection control part (13) sends a control signal indicating that said high-speed large-capacity data communication service will not be used to microcell base station (60). At this time, if there is a request for the low-speed data communication service provided by central base station (3) or the high-speed data communication service provided by a microcell base station from the aforementioned communication speed determination part (11), connection control part (13) carries out data communication with central base station (3) or one among microcell base stations (1a)-(1c) according to the aforementioned method.

[0159]

In the wireless communication system of this Application Example 6 described above, it is possible to provide a large-capacity data communication service at a speed higher than that in the high-speed data communication service provided by one microcell base station to terminal (5) by providing microcell base station controller (60), which controls a plurality of microcell base stations (1a)-(1c) and carries out large-capacity data communication with terminal (5), and carries out plural station multiple transmission of large-capacity data using a plurality of microcell base stations (1a)-(1c).

[0160]

Furthermore, the aforementioned high-speed large-capacity data communication service is provided by microcell base stations (1a)-(1c) located in the vicinity of terminal (5). Therefore, increase in the transmission power of said entire wireless communication system necessary for providing the high-speed large-capacity data communication service can be suppressed to a minimum.

[0161]

Furthermore, by being constituted to calculate the maximum communication speed capable of being provided based on the wireless resources capable of being used in the microcell base stations when there is a request to use the data communication service from terminal (5) and to provide the high-speed large-capacity data communication service within the range of said maximum communication speed, it is possible to provide a data communication service at the optimal communication speed without obstructing the data communication services being

provided to other terminals and the convenience of the wireless communication system can be enhanced.

[0162]

Incidentally, in the wireless communication system of this Application Example 6, a constitution wherein terminal (5) and microcell base stations (1a)-(1c) are wirelessly connected according to the CDMA system and terminal (5) carries out RAKE synthesis on the wireless signals respectively transmitted from microcell base stations (1a)-(1c) to synthesize the large-capacity data transmitted via plural station multiple transmission was shown as an example. However, it is not restricted to this type of constitution and can be other constitutions that synthesize and receive the data transmitted via plural station multiple transmission from a plurality of microcell base stations.

[0163]

For example, if microcell base stations (1a)-(1c) are to transmit a large-capacity data according to plural station multiple transmission using a single wireless carrier, a predetermined time offset is applied respectively to the data signals transmitted from microcell base stations (1a)-(1c). On the other hand, it can be constituted to carry out diversity synthesis and reception with a plurality of data signals containing the aforementioned time offset as multiple pass multiplex signals by providing a compatible equalization function to connection control part (13) of terminal (5). Also, even in a multi-carrier system wherein microcell base stations (1a)-(1c) are wirelessly connected to terminal (5) using a plurality of wireless carriers, the terminal (5) provided with compatible equalization function can be constituted to carry out diversity syntheses and reception, with the data signals transmitted from the aforementioned microcell base stations as multiple pass multiplex signals.

[0164]

Also, microcell base station controller (60) in this Application Example 6 carries out plural station multiple transmission of large-capacity data using all microcell base stations (1a)-(1c) capable of providing high-speed communication service specified according to base station position information database (7) when the maximum communication speed capable of being provided is faster than the requested data communication speed. However, it is not restricted to this constitution, and plural station multiple transmission of large-capacity data may be carried out using sufficient microcell base stations for satisfying the requested data communication speed.

[0165]

For example, a high-speed large-capacity data communication service may be provided at the requested data communication speed by microcell base station controller (60) selecting two optional stations from among microcell base stations (1a)-(1c) capable of providing the aforementioned high-speed data communication service when the requested data communication speed is 40 Mbit/sec, the maximum communication speed capable of being provided is 60 Mbit/sec, and the communication speed per each microcell base station is 20 Mbit/sec. In the case of this type of constitution, increase in the transmission power of said entire wireless communication system necessary for providing a high-speed large-capacity data communication service can be suppressed even more.

[0166]

Application Example 7

In this Application Example 7, when a data communication request is generated from terminal (5), the communication speeds of the data communication services capable of being provided by central base station (3) and microcell base stations (1a)-(1e) are notified to terminal (5), and the user of said terminal (5) selects the data communication service to be used based on said communication speeds. Incidentally, the wireless communication system of this Application Example 7 varies from the wireless communication system of Application Example 6 only in the point that base station position information database (7) extracts the data communication services capable of being provided to terminal (5) and notifies terminal (5), and the remainder of the communication control process is identical. Therefore, only the process for notifying the data communication services capable of being provided to terminal (5) and terminal (5) selecting the data communication speed will be explained below. Also, explanation of the identical constitution as Application Example 6 will be omitted by appending the same reference letters and numbers.

[0167]

First of all, when a data communication request is generated from a user application of terminal (5), communication speed determination part (11) makes an inquiry to connection control part (13) about the usable data communication speeds. Next, connection control part (13) obtains the current position information of said terminal (5) via position information generation part (12) and transmits a control signal of inquiry about the data communication services that includes the current position information of said terminal (5) to central base station (3).

[0168]

Next, central base station (3) transmits the position information of terminal (5) and makes an inquiry to base station position information database (7) about the data communication services capable of being provided. Next, base station position information database (7) specifies the microcell base stations capable of providing high-speed data communication service to said terminal (5) based on the position information of said terminal (5).

[0169]

When a plurality of microcell base stations are specified as being able to provide high-speed data communication service to the aforementioned terminal (5), base station position information database (7) notifies said specified plurality of microcell base stations to microcell base station controller (60) and inquires about the maximum communication speed capable of being provided in the high-speed large-capacity data communication service if plural station multiple transmission is carried out via said specified plurality of microcell base stations.

[00170]

Next, base station position information database (7) transmits a control signal containing the communication speed of low-speed data communication service according to the aforementioned central base station (3), the communication speed of high-speed data communication service according to the aforementioned specified microcell base stations, and the maximum communication speed of the high-speed large-capacity data communication service according to plural station multiple transmission that was calculated by the aforementioned microcell base station controller (60) to the aforementioned terminal (5) via central base station (3).

[0171]

Next, communication speed determination part (11) of terminal (5) notifies the user application from which the data communication request was made about the communication speed of each data communication service transmitted from the aforementioned base station position information database (7). The user application selects the data communication service to be used based on the communication speed of the aforementioned usable data communication services and responds to communication speed determination part (11). Next, communication speed determination part (11) makes a request to connection control part (13) to start the data communication service selected according to the aforementioned user application, and data communication is started between terminal (5) and central base station (3) or microcell base stations (1a)-(1e).

[0172]

As described above, in this Application Example 7, the data communication services capable of being provided to said terminal (5) are extracted when a data communication request is generated from terminal (5) and the user selects the optimal data communication service based on the communication speeds of said extracted data communication services. Therefore, the user of terminal (5) can optionally select the optimal data communication service from among the usable data communication services and the convenience of the data communication terminal can be enhanced.

[0173]

Incidentally, in this Application Example 7, terminal (5) requesting the data communication obtains the position information via position information generation part (12) and base station position information database (7) extracts the data communication services capable of being provided to terminal (5) based on the aforementioned position information. However, obtaining the position information by terminal (5) is not restricted to said method and the position information of terminal (5) in central base station (3) may be estimated as in Application Example 2.

[0174]

Also, the user application from which the data communication request was made selects the data communication service to be used based on the communication speeds of the data communication services notified from communication speed determination part (11). However, selection of data communication service according to the user application is not restricted to said method and it is possible, for example, to store in advance the use fee per unit time of each data communication service in communication speed determination part (11), notify about the use fee per unit time and the communication speeds of the data communication services to the user application, and the aforementioned user application selecting the data communication service to be used based on these information. In such case, the user of terminal (5) can select the optimal data communication service by giving consideration also the use fee of the data communication services in addition to the aforementioned communication speed.

[0175]

Effects of the invention

As described above, the present invention manifests an effect of being able to suppress the increase in the transmission power of said entire wireless communication system even if the

speed of the data communication service is enhanced due to having been constituted to provide high-speed data communication service by providing microcell base stations capable of using microcells which can carry out high-speed data communication, and the communication available area is small within a macrocell used by a central base station and using microcells to the aforementioned microcell base stations, limited only to when request for high-speed data communication service was generated in a terminal.

[0176]

Also, the present invention manifests an effect of being able to suppress the increase in the transmission power of said entire wireless communication system due to having been constituted by providing a plurality of microcell base stations within the aforementioned macrocell, providing a base station position information database with the positions of the microcell base stations stored, said base station position information database specifying the microcell base stations capable of providing high-speed data communication service based on the current position information transmitted from the terminal, and using only the microcells to the microcell base stations located in the vicinity of the aforementioned terminal.

[0177]

Also, the present invention manifests an effect of being able to provide high-speed data communication service always from a microcell base station located in the vicinity of the terminal and being able to enhance the mobility of the terminal using the high-speed data communication service, even if the terminal carrying out the high-speed data communication moves, the aforementioned base station position information database being constituted to specify the microcell base station based on the position information of said terminal.

[0178]

Also, the present invention manifests an effect of being able to suppress the increase in the transmission power of the entire wireless communication system due to having been constituted by providing a terminal position estimation means that estimates the position of the terminal based on the wireless signals transmitted from the terminal to the aforementioned central base station, said terminal position estimation means estimating the terminal position when a request for high-speed data communication service is generated, the aforementioned base station position information database specifying the microcell base stations capable of providing said high-speed data communication service based on said estimated position information, and using the microcells only to said specified microcell base stations. Also, the present invention manifests an effect of being able to achieve miniaturization and decrease in the power

consumption of the terminal since it is not necessary to provide a position detection means to the terminal such as GPS or the like, which detects the position information.

[0179]

Also, the present invention manifests an effect of being able to further enhance the convenience of the data communication terminal by the communication speed determination means being constituted to make an inquiry to the base station position information database about the communication speed of the data communication services capable of being used by said terminal before starting the data communication, for the base station position information database to calculate the maximum communication speeds of the data communication services capable of being provided to said terminal and respond to said terminal, and for the user to optionally select the optimal data communication service based on said maximum communication speeds when a request for data communication is generated from a terminal.

[0180]

Also, the present invention manifests an effect of being able to enhance the mobility of the terminal while suppressing the degradation in the communication quality of high-speed data communication by being constituted to provide high-speed data communication service by providing a quality request determination means that determines the communication quality necessary when carrying out high-speed data communication to the terminal and the microcell base stations specified according to the aforementioned base station position information database using the microcells wherein the cell radius was expanded when a high quality high-speed data communication service is requested by said terminal.

[0181]

Also, the present invention manifests an effect of being able to enhance the mobility of the terminal while suppressing the degradation in the communication quality of high-speed data communication the aforementioned base station position information database being constituted to specify all the microcell base stations within a predetermined area that includes said terminal and to transmit data to the aforementioned terminal from all of said specified microcell base stations when there is a request for high quality high-speed data communication service from a terminal.

[0182]

Furthermore, the present invention manifests an effect of being able to suppress the increase in the transmission power of said entire wireless communication system since high-

speed data communication service is provided automatically according to normal microcells when the terminal is moving at a low-speed by providing a moving speed detection means to the terminal and the aforementioned quality request determination means discriminating whether or not to make a high quality communication request based on the moving speed of the terminal detected by said moving speed detection means.

[0183]

Also, the present invention manifests an effect of being able to provide a high-speed and large-capacity data communication service according to a request from a terminal while suppressing the increase in the transmission power of said entire wireless communication system by providing a microcell base station control means that controls a plurality of microcell base stations to the wireless communication system, the aforementioned connection control part transmitting a control signal requesting a high-speed large-capacity data communication service, and the aforementioned microcell base station control means that received said control signal transmitting large-capacity data according to plural station multiple transmission via a plurality of microcell base stations located in the vicinity of said terminal that were specified according to the aforementioned base station position information database when the communication speed determination speed of the aforementioned terminal determines that data communication of higher speed and larger capacity than the high-speed data communication service provided by one of the aforementioned microcell base stations is necessary.

[0184]

Furthermore, the present invention manifests an effect of being able to provide a high-speed large-capacity data communication service without obstructing the wireless connection services for other terminals in addition to the aforementioned effects by the aforementioned connection control means being constituted to transmit a control signal of high-speed large-capacity data communication service request made by the aforementioned terminal by including the information related to the requested communication speed, for the aforementioned microcell base station control means to calculate the maximum communication speed capable of being provided by the plurality of microcell base stations specified according to the base station position information database, compare said maximum communication speed to the aforementioned requested communication speed, and to make an inquiry to the aforementioned terminal regarding whether or not to carry out the high-speed data communication at said maximum communication speed when said maximum communication speed is a lower speed than the aforementioned requested communication speed.

[0185]

Also, the present invention manifests an effect of being able to use microcells capable of carrying out high-speed data communication only to the vicinity of the terminal while suppressing the transmission power of the data transmitted from the central base station and to suppress the increase in the transmission power of the entire wireless communication system due to a constitution such that the central base station transmits data to the terminal at a predetermined transmission power that was determined based on the maximum transmission power of said central base station and the number of terminals that was estimated in advance, a repeater that amplifies and retransmits the data signals transmitted from said central base station is provided within the macrocell, and the terminal carries out the high-speed data communication via said repeater.

[0186]

Also, the present invention can be used to carry out charge management complying to the use status of the wireless and hardware resources of said wireless communication system, enhance the convenience in the data communication of the terminals, and can enhance the convenience in charge management of the wireless communication system by providing a user charge database that calculates the total communication time of the terminal individually for each data communication service provided by said wireless communication system.

Brief description of the figures

Figure 1 is a block diagram of the wireless communication system in Application Example 1 of the present invention.

Figure 2 is a block diagram of the terminal in Application Example 1 of the present invention.

Figure 3 is an explanatory diagram showing the base station position information stored in the base station position information database in Application Example 1 of the present invention.

Figure 4 is a block diagram of the receiving part of the central base station in Application Example 2 of the present invention.

Figure 5 is a block diagram of the wireless communication system in Application Example 3 of the present invention.

Figure 6 is a block diagram of the repeater in Application Example 3 of the present invention.

Figure 7 is a block diagram of the wireless communication system in Application Example 4 of the present invention.

Figure 8 is a block diagram of the terminal in Application Example 4 of the present invention.

Figure 9 is an explanatory diagram showing an example of the recording in user charge database in Application Example 4 of the present invention.

Figure 10 is an explanatory diagram showing how the high-speed data communication service is provided by microcell base stations in the wireless communication system in Application Example 5 of the present invention.

Figure 11 is a block diagram of the wireless communication system in Application Example 6 of the present invention.

Figure 12 is an explanatory diagram showing how high-speed large-capacity data communication service is provided by microcell base stations in the wireless communication system in Application Example 6 of the present invention.

Figure 13 is a block diagram of a conventional wireless communication.

Explanation of symbols

(1a), (1b), (1c), (1d), (1e)	microcell base station
(2a), (2b), (2c), (2d), (2e), (102)	microcell
(3), (103)	central base station
(4), (104)	macrocell
(5), (105)	terminal
(6)	communication network
(7)	base station position information database
(8)	user charge database
(11)	communication speed determination part
(12)	position information generation part
(13)	connection control part
(21)	array antenna
(22)	A/D
(23)	direction detection part
(24)	reception intensity measurement part
(25)	terminal position estimation part
(26)	propagation loss profile
(27)	base station control part
(30a), (30b)	repeater
(31)	receiving antenna
(32)	auxiliary antenna

(33)	antenna canceller
(34)	phase · amplitude control part
(35)	synthesizer
(36)	wraparound canceller
(37)	delay time estimation part
(38)	memory
(39)	correlation processing part
(40)	transmission route estimation part
(41)	replica generation part
(43)	subtractor
(44)	low distortion transmission amplifier
(45)	retransmission antenna
(50a), (50b), (50c)	expanded microcell
(51)	quality request determination part
(52)	moving speed detection part
(55)	area of predetermined distance R from terminal
(5), (60)	microcell base station controller
(101)	base station

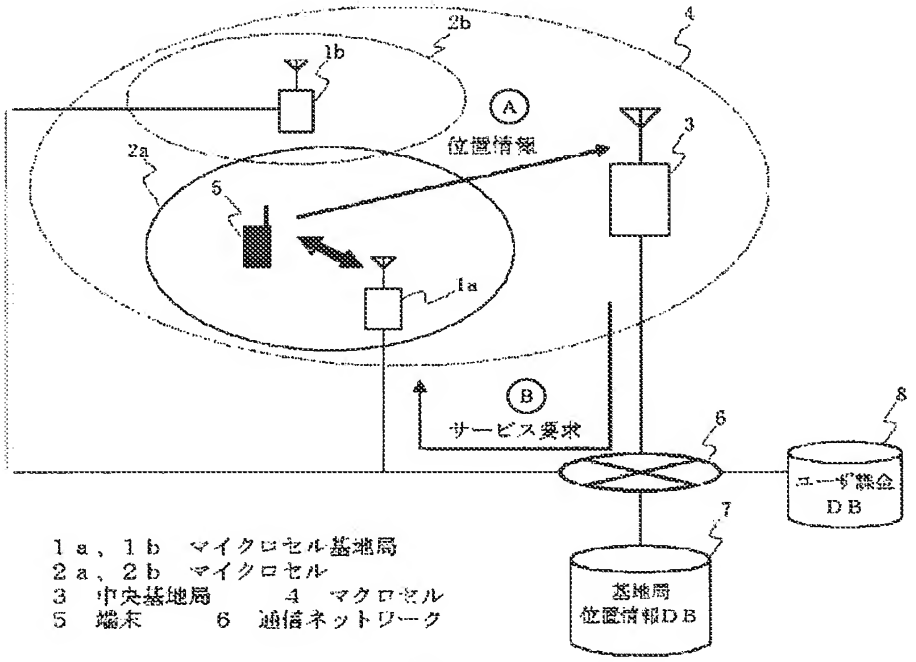


Figure 1

Legend:

	1a, 1b	Microcell base station
	2a, 2b	Microcell
	3	Central base station
	4	Macrocell
	5	Terminal
	6	Communication network

Key:

	A	Position information
	B	Service request
	7	Base station position information DB
	8	User charge DB

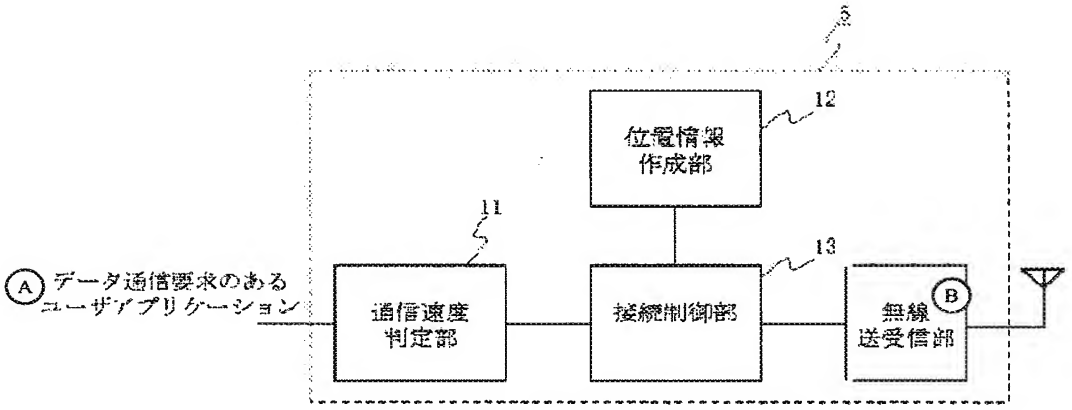


Figure 2

Key:

	A	User application that has data communication request
	B	Wireless transmission and receiving part
	11	Communication speed determination part
	12	Position information generation part
	13	Connection control part

1	2	4	5	6
基地局識別情報	基地局位置	セル半径	送信電力	通信速度
3	北緯＊ 東経＊	3Km	25W	低速のみ (～9.6kbps) 7
1a 3	北緯＊ 東経＊	100m	0．6W	高速対応可 (～20Mbps) 8
1b	北緯＊ 東経＊	100m	0．6W	高速対応可 (～20Mbps) 9
：	：	：	：	：

Figure 3

Key 1 Base station identification information

2 Position of base station
3 North latitude East longitude
4 Cell radius
5 Transmission power
6 Communication speed
7 Low-speed only
8 Can accommodate high-speed
9 Can accommodate high-speed

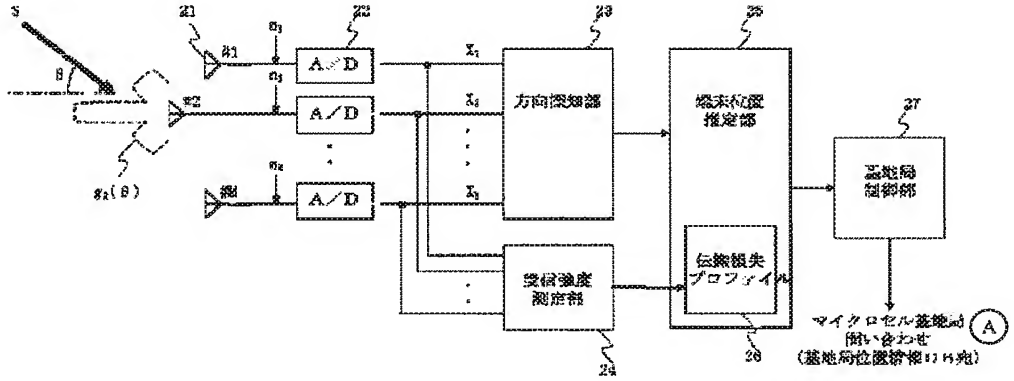


Figure 4

Key: A Inquiry of microcell base station (Base station position information addressed to H)
23 Direction detection part
24 Reception intensity measurement part
25 Terminal position estimation part
26 Propagation loss profile
27 Base station control part

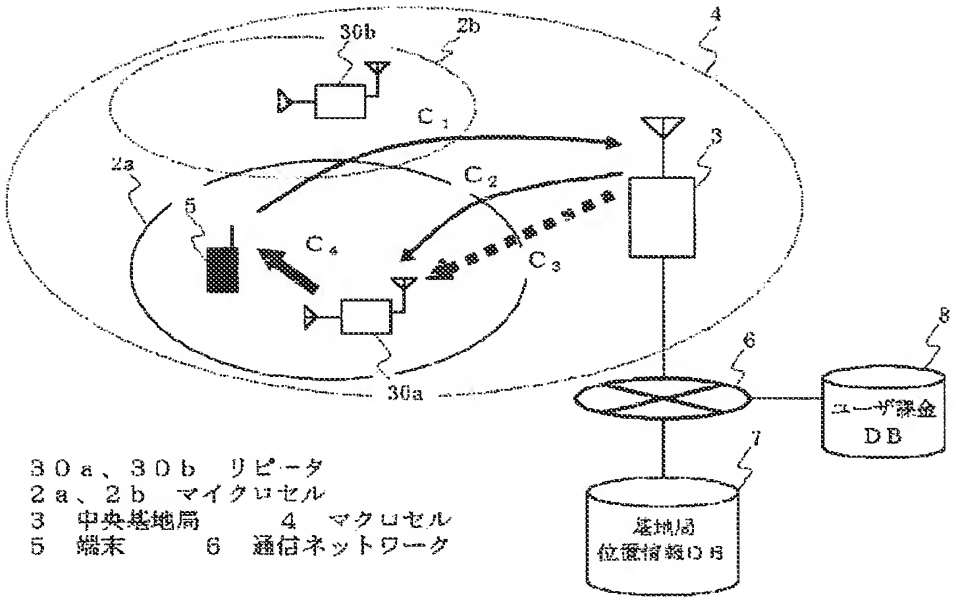


Figure 5

Legend:	30a, 30b	Repeater
	2a, 2b	Microcell
	3	Central base station
	4	Macrocell
	5	Terminal
	6	Communication network
Key:	7	Base station position information DB
	8	User charge DB

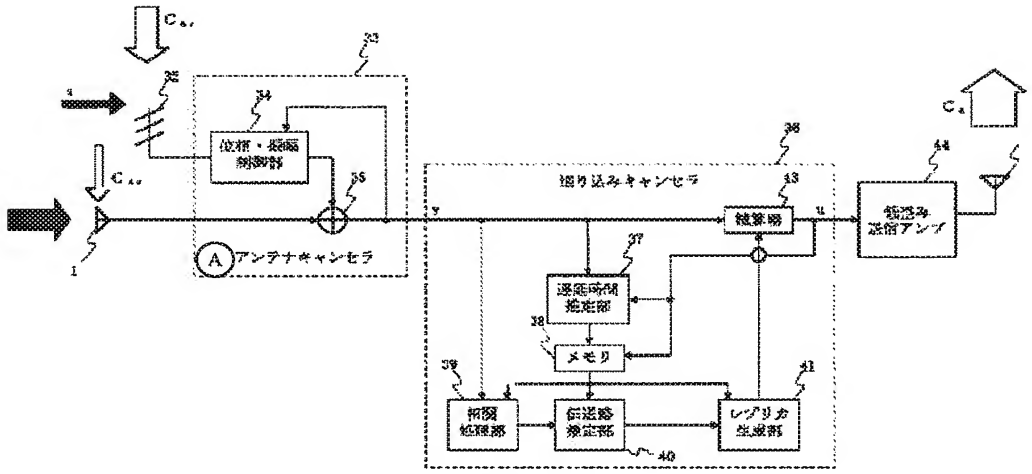


Figure 6

Key:
- A Antenna canceller
- 34 Phase · amplitude control part
- 36 Wraparound canceller
- 37 Delay time estimation part
- 38 Memory
- 39 Correlation processing part
- 40 Transmission route estimation part
- 41 Replica generation part
- 43 Subtractor
- 44 Low distortion transmission amplifier

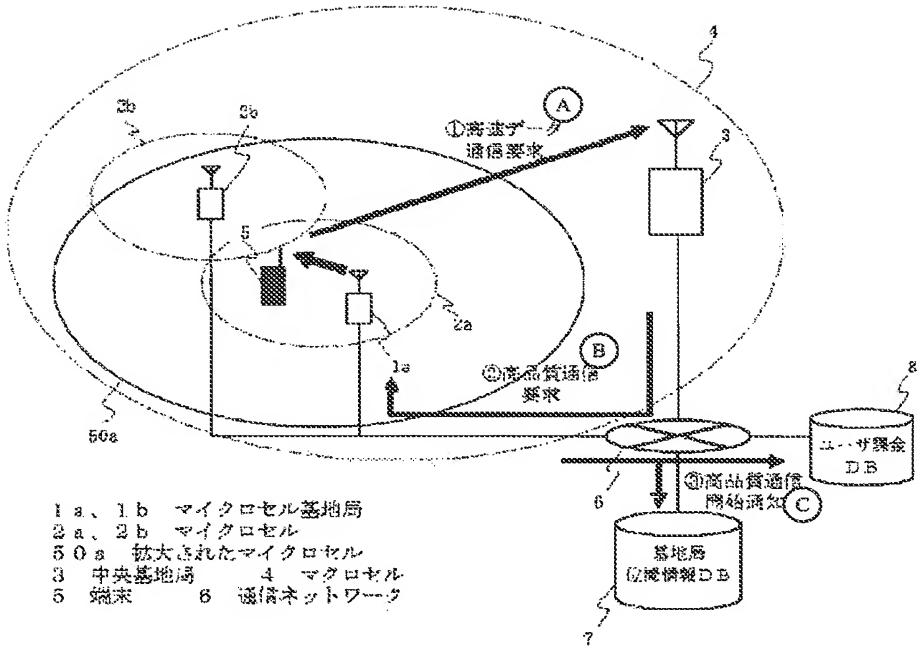


Figure 7

Legend:	1a, 1b	Microcell base station
	2a, 2b	Microcell
	50a	Expanded microcell
	3	Central base station
	4	Macrocell
	5	Terminal
	6	Communication network
Key:	A	High-speed data communication request
	B	High quality communication request
	C	High quality communication start notification
	7	Base station position information DB
	8	User charge DB

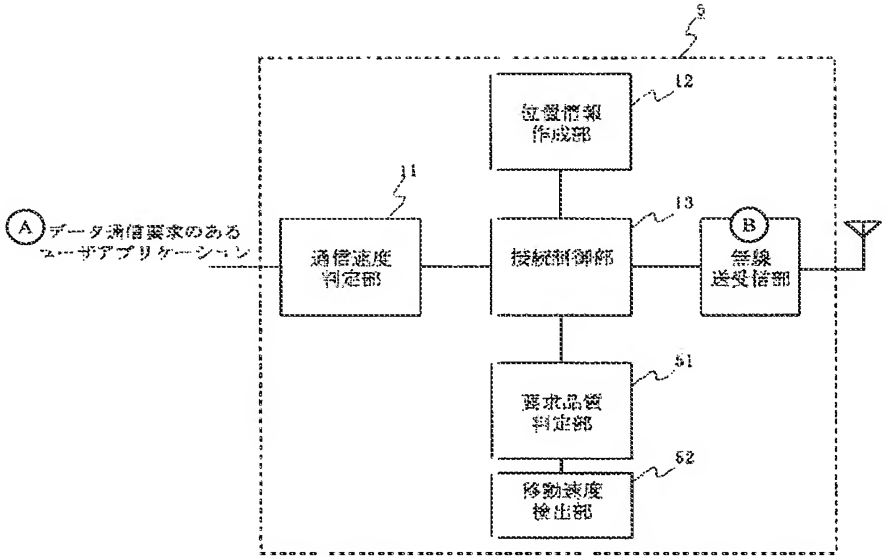


Figure 8

Key: A User application that has data communication request
B Wireless transmission and receiving part
11 Communication speed determination part
12 Position information generation part
13 Connection control part
51 Quality request determination part
52 Moving speed detection part

1 接続基地局	5 低速通信	7 高速データ通信	10 高品質・高速データ通信
S	11/3 10:31:50 11/3 10:35:11		
1 a			11/3 18:30:50 11/3 19:46:25
S	11/4 8:15:45 11/4 8:35:50		
1 b		11/5 12:10:50 11/5 14:55:25	
⋮	⋮	⋮	⋮
2 総通信時間	8h04m30s	4h50m05s	1h15m10s
3 単位時間当りの利用料	5a 10 円/m	8 30 円/m	60 円/m 11
4 通信料金	6 4840 円	9 8100 円	3756 円 12

Figure 9

Key 1 Connected base station
2 Total communication time
3 Use fee per unit time
4 Communication charge
5 Low-speed communication
5a 10 yen/m

6	4840 yen
7	High-speed communication
8	30 yen/m
9	8100 yen
10	High quality · High-speed data communication
11	50 yen/m
12	3750 yen

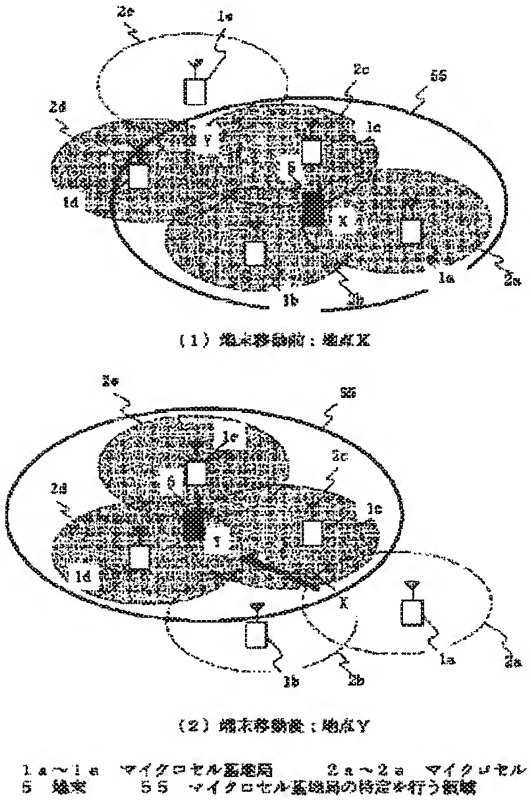


Figure 10

Legend:	1a-1e	Microcell base station
	2a-2e	Microcell
	5	Terminal
	55	Area for specifying the microcell base stations
Key:	(1)	Before the terminal moved: Spot X
	(2)	After the terminal moved: Spot Y

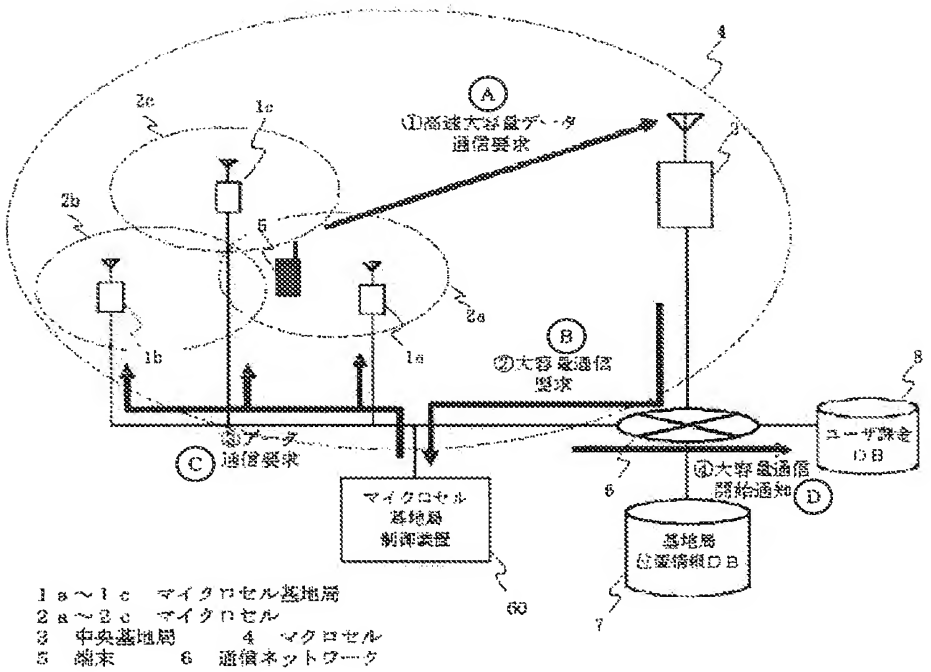
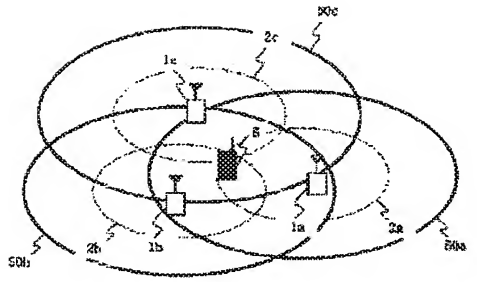


Figure 11

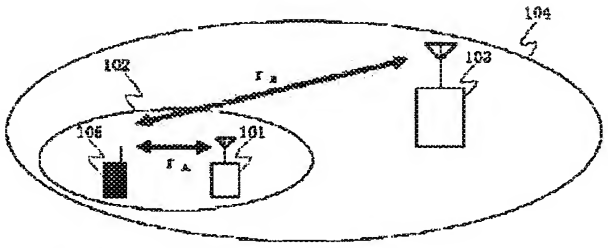
Legend:	1a-1c	Microcell base station
	2a-2c	Microcell
	3	Central base station
	4	Macrocell
	5	Terminal
	6	Communication network
Key:	A	High-speed large-capacity data communication request
	B	Large-capacity communication request
	C	Data communication request
	D	Large-capacity communication start notification
	7	Base station position information DB
	8	User charge DB
	60	Microcell base station controller



1a～1c マイクロセル基地局　　2a～2c マイクロセル
5 端末　　50a～50c 拡大されたマイクロセル

Figure 12

Legend:
1a-1c	Microcell base station
2a-2c	Microcell
5	Terminal
50a-50c	Expanded microcell



101 基地局　　102 マイクロセル
103 中央基地局　　104 マクロセル　　105 端末

Figure 13

Legend:
101 Base station
102 Microcell
103 Central base station
104 Macrocell
105 Terminal

Continued from front page

F terms (for reference) 5K033 AA04 DA01 DA19 DB20 EA03
5K067 AA21 AA43 BB04 DD29 DD53
EE02 EE10 EE16 HH21 HH23
JJ39 JJ52 JJ56 JJ66